CONFINED SPACE ENTRY WORKSHOP

Training & Certification

Environment Ontario

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Minister

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CONFINED SPACE ENTRY WORKSHOP

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INTRODUCTION

The Confined Space Entry Workshop based on this manual covers five days at the Ministry of the Environment Training Facilities. The workshop consists of lectures, demonstrations and hands-on training in confined space entry and procedures.

The principal objective of the workshop is to teach the confined space worker safe practices and procedures required for entry into confined spaces. The lesson objectives are clearly outlined at the beginning of each topic, and inform the trainee of what he should know or do after having covered that topic. In order to successfully complete the workshop, an overall average of 70% is required, based upon daily tests, hands-on performance and a final exam.

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CONFINED SPACE ENTRY WORKSHOP

TOPIC: 1

Occupational Health and Safety Act

OBJECTIVES:

The trainee will be able to:

1. Define the purpose of the O.H.S.A.

2. Identify the responsibilities under the act of the;

   a) Employer
   b) Supervisor
   c) Worker

3. Define a "Competent Person".

OCCUPATIONAL HEALTH AND SAFETY ACT

GENERAL

The Occupational Health & Safety Act is the LAW in Ontario and is administered by the Ministry of Labour. It is applicable to almost all workers in Ontario and to the Crown. It is designed to protect the worker from ill health, injury or death in the work environment.

The legislation and the books are divided into two distinct sections, the Act and the Regulations.

The Act

The "Act" can be compared to a building foundation. The Act is the "enabling" legislation for the regulations. Under the powers of the Act, regulations can be altered, expanded, or new and additional regulations can be issued without being passed through the Ontario Legislature. The Act contains the following information:

1. Definitions of words and terms used in the Act.
2. Exemptions from the Act.
3. Powers of Minister, Deputy Ministers and Inspectors.
4. Health & Safety Committees and their powers.
5. Advisory Committees.

6. Duties of Constructors, Employers, Supervisors, Workers, Owners and Suppliers.
7. Toxic substances.
8. Refusal to work.
9. Reporting of Accidents.
10. Enforcement of the Regulations.
11. Offences and Penalties.

The Regulations

The Act is the foundation of the Occupational Health & Safety Act. Similarly the Regulations, is the "house" built on the foundation.

Due to the vast differences in work environments, the Regulations have been written to cover 3 distinct work environments. They are:

1. Mining.
2. Construction, and
3. Industrial Establishments.

While water and wastewater activities are outlined in the Industrial Section, it should be remembered that if construction is to be done in an industrial establishment, then the Regulations of the construction Section as well as those of the Industrial Section must be observed. Many of these regulations are the same, but have different numbers in the various sections.

For instance, Regulation 1(c) in the Industrial Section is similar to Regulation 691, Section 119 (1) of the Regulations for Construction Projects.

REGULATION 692

under the Occupational Health and Safety Act

INDUSTRIAL ESTABLISHMENTS

INTERPRETATION

1. In this Regulation,

(c) "confined space" means a space in which, because of its construction, location, contents or work activity therein, the accumulation of a hazardous gas, vapour, dust or fume or the creation of an oxygen-deficient atmosphere may occur;

CONFINED SPACES

119.—(1) In this section, "confined space" means a place,

(a) to which or from which the means of access or egress are restricted because of location, design, construction, or contents; and

(b) in which,

(i) a hazardous accumulation of gas, vapour, dust, mist or smoke may be present, or may accumulate, or

(ii) there may be an oxygen content in the atmosphere of less than eighteen per cent or more than twenty-three per cent,

and includes an open or enclosed tank, vat, sewer, pipe, duct, flue, reactor, chamber and other such spaces. O. Reg. 659/79, s. 119 (1).

Essentially both of the above pieces of legislation are the same in their intent.

Figure 1-1

Essentially both pieces of legislation are the same in their intent.

While the regulations may be different for the various sections, the Act for all sections is identical. Figure 1-1 illustrates this fact. Like the Act, the Regulations contain definitions of words and terms used to provide a solid base of understanding and avoid misinterpretation.

It should be noted that the Act and the Regulations appear very formal and detailed. The Act and the Regulations are written in "legal language" which must be precise since they will be used in legal proceedings when charges are laid. Also, they must be legally enforceable.

The Regulations are the rules which everyone must live by in the work environment. Emphasis is placed on the fact that the regulations are only MINIMUMS which must be met in the workplace. While the Regulations can be exceeded in the interest of Health & Safety with no fear of repercussions, working to a lesser standard than that required by the Regulations is an offense that can result in a court appearance, fines and/or imprisonment for the offenders.

Terms & Definitions

In the drafting of any legislation it is necessary to use words or phrases that have a unique definition. The definitions must be specific enough that there is only one legal context that

the word or phrase can have. The use of this legal terminology is very accurate at describing a concept or an intent of law. However, most people have a difficult time comprehending the legal terminology.

Words or phrases that have multiple meanings and used in legal text have to be defined as to their application under the law. The "definitions" sections in any Act or Regulation strictly defines the application of a particular word or phrase. The definition only will apply to the specific legal document in which it was defined. It is interesting to note that the same word can mean two entirely different things in two different pieces of legislation. For this reason, it is imperative that when any legislation is interpreted, the person doing so should be well familiarized with the definitions contained in the document.

Employer Responsibilities Under the Act

Who is an employer? The word "employer" means anyone who employs one or more workers or who contracts for the services of one or more workers. It includes a contractor or a sub-contractor.

The following are the Responsibilities of an employer.

1. Provide the equipment, materials and protective devices which are required by the Act and/or the Regulations.

2. Ensure that all equipment, materials, and protective devices are maintained in a serviceable state. It is not sufficient for the employer to provide the equipment, materials and/or protective devices for the workers, he is also charged with maintaining them.
3. Ensure that all equipment, materials, and protective devices which have been provided are used in the proper manner. It is not sufficient for the employer to provide and maintain the equipment, material and/or protective devices. He must also ensure that they are used in a proper manner.
4. Ensure that the workers are provided with measures and procedures for their safety and protection in the workplace.
5. Ensure that the workers are trained in the use of the equipment, materials and protective devices which have been provided. The employer is responsible to ensure that the workers are trained in the use of the equipment, materials and/or protective devices. This can require re-training and practice with the items on an on-going basis and at the proper intervals.
6. Ensure that the structure in which the workers are employed is structurally sound and is safe.

7. Provide information, instruction and supervision to a worker to protect their health and safety in the workplace.

8. When the employer appoints a supervisor, the employer must appoint a COMPETENT PERSON.

9. Make known to a worker, or to a person having authority over a worker, any hazards in the workplace and/or any hazards in the handling, use, storage, disposal and transport of anything which can be harmful to the health or safety of a worker.

10. Not knowingly permit anyone under the age of 16 to work in the workplace.

11. In all circumstances take all reasonable precautions for the safety of the workers at all times.

12. Post a copy of the O.H.S.A. and any explanatory material prepared by the Ministry of Labour in a prominent place in the workplace where it will be available to the workers at all times. Note that the O.H.S.A. Act and Regulations are required to be posted in a PROMINENT place to make them available to the workersAT ALL TIMES. They must also be in English and the majority language of the workplace.

Under Section 15 of the Act, there are a number of other duties in regard to health records, safety committees, etc., which the employer must meet but they are not pertinent to this course.

Supervisor Responsibilities Under the Act

Who is a Supervisor? According to the Act any person who has authority over a worker and receives extra money to supervise, is a supervisor. The following are the responsibilities of a supervisor.

1. Ensure that the worker wears the equipment and protective devices which are required and which are provided.
2. Ensure that the worker follows the measures and procedures which are required for the protection and health of the worker.
3. Advise the worker of any potential or actual hazard to health or safety of which the supervisor is aware.
4. Where necessary provide a worker with written instruction as to the measures and procedures to be followed for the protection of the worker.
5. Take all reasonable precaution for the protection of the worker at all times.

The employer provides the protective devices and equipment as well as the procedures which are to be followed for the protection of the worker. The supervisor has to ensure that the worker has the protective equipment and devices, knows how to use them correctly, has a knowledge of the work to be done and knows the procedures to be followed to enable the work to be done without danger to the worker, or to any other person.

It should be noted that where the workplace is remote from the location of the supervisor, and provided all the conditions stated have been met, the worker in effect supervises him/herself, but not as a supervisor.

Where a new and/or dangerous or toxic substance is to be used by a worker who has not, in the recent past, been in contact with it, the supervisor must make the worker aware of the hazards and the procedures for the safe use and handling of the substance. The supervisor must also ensure that the proper protective equipment and devices are provided, and ensure that the worker is trained in the use of the protective devices and equipment.

Where a work site is involved, and the worker has not previously been in a similar area, the employee must be instructed not to enter the workplace unless accompanied by a competent person who is aware of the hazards, and can inform the worker of them, and the protective measures which must be taken for the safety and health of the worker.

Where a safety procedures manual exists, or where procedures are in written form, the supervisor shall ensure that the worker is aware of, and has access to at all times, the information which is applicable to their work.

Worker Responsibilities Under The Act

Who is a worker? Any person who performs work or supplies a service of any kind in exchange for money is a worker.

From what has been learned in regard to the duties of an employer and a supervisor, it might appear that they carry the full responsibility of the safety and health of the workers, while the workers have no responsibility at all.

The worker also has responsibilities and duties under the Act and the Regulations which are just as important as those of the employer and the supervisor. The responsibilities of a worker are as follows:

1. The worker must work in accordance with the requirements of the Act and the Regulations at all times. This places a direct responsibility on the worker to be familiar with the Act and the Regulations, just as the supervisor and the employer are required to be familiar with them.

2. Where protective devices and equipment are provided, and are required under the Act or Regulations, the worker must wear and use them.
3. Where a hazard or defect exists and the worker becomes aware of it, the worker must advise the supervisor or employer (preferably in writing), of the location and nature of the defect or hazard for the protection of themselves and all others in the workplace.
4. Where a worker becomes aware of a part of the Act or Regulations which is being contravened, the worker must make the contravention known to the supervisor or the employer (preferably in writing).
5. Where prescribed by regulation that medical surveillance is necessary, the worker must submit to the medical practices which will provide the information required.
6. Where the Act or Regulations require that a protective device be in place, the worker must not remove it or make it ineffective without first notifying the supervisor. He must also provide a temporary safeguard and when the need for the removal of the protective device no longer exists, the worker must replace the protective device.
7. The worker must not use or operate any equipment which may endanger himself or any other worker.

8. The worker must work in a manner which will not endanger himself or any other person.

9. The worker shall not engage in "horseplay" or pranks, feats of strength, unnecessary running, or rough and rowdy conduct in the workplace.

From the above duties it can be seen that worker safety is not only dependent on the employer and the supervisor adhering to the conditions of the Act and Regulations, but that the worker has a definite responsibility for his own safety and the safety of other workers in the workplace.

Definition of a "Competent Person"

Under Section 14 of the Act, the employer is charged with the responsibility, when appointing a supervisor, to ensure that a competent person is appointed. This is a major requirement which must be met by the employer. In order to be a competent person, a supervisor must have the following qualifications:

1. Be familiar with the Act and Regulations, and their provisions in regard to the health and safety of the workers. Unless the supervisor is familiar with the Act and Regulations and knows what they cover, he is not a competent person, regardless of experience or years in the employ of the firm for which they work.

2. Be qualified by knowledge of the work, training in the work and experience to be able to organize the work and ensure that it is done in a safe manner. This provision requires three criteria, namely knowledge of the work, training in the work and experience in the work in order to be judged as being competent. In addition, it is not sufficient for a supervisor just to have these qualities, the supervisor must also be able to organize the work and <u>ENSURE</u> that it is done in a safe manner.

3. Have knowledge of any potential or actual hazard to the health or safety of the workers in the workplace. This stipulation makes it mandatory that a supervisor keep up to date on developments and the criteria to ensure the health and safety of those who are being supervised.

If an employer appoints a person as supervisor and by reason of an accident, the supervisor is not judged to have been a competent person, then in addition to the supervisor being charged, the employer can be charged with the same offense, and with a second charge of having appointed a non-competent person as a supervisor. Where an accident occurs the supervisor must <u>ensure</u> that every reasonable precaution in the circumstances was taken for the protection of the worker.

Summary

1. The Occupational Health & Safety Act and Regulations are LAW in Ontario. These laws are designed to protect you and your fellow workers from injury and/or death in the workplace.
2. The Act is the enabling legislation or the foundation on which the Regulations are built.
3. The Regulations are the "Rules" by which all must live.
4. The Regulations are the MINIMUM requirements which must be observed.
5. Employers, Supervisors and Workers all have duties under the Act.
6. A "Competent Person" is defined by the Act.
7. Workers have responsibility for themselves and other workers.
8. Supervisors must be "competent" under the Act.

SUBJECT: TOPIC: 2

CONFINED SPACE ENTRY WORKSHOP

Confined Space Characteristics & Hazards

OBJECTIVES:

The trainee will be able to:

1. Give the definition of a confined space under the Occupational Health and Safety Act (OHSA).

2. List 3 categories of atmospheric hazards that can occur in a confined space.

3. Identify other confined space hazards.

4. State the minimum and maximum oxygen levels required for safe entry into a confined space.

CONFINED SPACE CHARACTERISTICS & HAZARDS

GENERAL

In the operation of water and wastewater treatment facilities, wastewater collections systems and water distribution systems entry into confined spaces is unavoidable. Confined spaces may contain elements which are a threat to the health and/or safety of those who enter.

While entry to confined spaces is unavoidable, the hazards present can be avoided provided the worker is aware of two basic factors. They are:

1. What factors contribute to determine that an area is a confined space; and
2. What other areas in the work environment are considered confined spaces.

DEFINITION OF A CONFINED SPACE

Industrial Establishments

Under Regulation 1 (c) of the Industrial Establishments Regulations, a confined space is defined as follows:

> "Confined space means a space in which, because of its construction, location, contents, or work activity therein, the

accumulation of a hazardous gas, vapour,
dust or fume or the creation of an oxygen
deficient atmosphere may occur"

This means that a confined space can be large, small, located below, at or above grade. The size, configuration and elevation are not factors in determining if an area is a confined space. The work or activity in an area can make it a confined space under the regulations. Equipment in an area which consumes oxygen and/or emits a hazardous gas, vapour, dust or fume can make an area a confined space.

Attention should be drawn to the last two words in the definition - <u>MAY OCCUR</u>. The regulation does not state that a hazardous gas, vapour or fume <u>WILL</u> or <u>MUST</u> be present. Instead, it stipulates that if the possibility exists of one or more of the hazards being present, the area becomes a confined space under the Regulation.

<u>Construction Projects</u>

Regulation 119 (1) states the following:

"In this section, "Confined Space" means a place,

a) to which or from which the means of access or egress are restricted because of location, design, construction or contents; and

b) in which,

i) a hazardous accumulation of gas,

vapour, dust, mist or smoke may be present, or may accumulate, or;

ii) there may be an oxygen content in the atmosphere of less than eighteen percent or more than twenty-three percent, and includes an open or enclosed tank, vat, sewer, pipe, duct, flue, reactor, chamber and other such spaces.

It is interesting to note that there are several differences in the format of this definition and the definition given for a confined space for Industrial Establishments. An examination of the Regulations for Industrial Establishments will reveal that, in reality, the intentions are identical. In part (a), access and egress conditions are stipulated. Section 72 (a) of the Industrial Establishments covers this same situation and makes the same stipulation.

Part (b) (i) includes the words, "mist or smoke". In the definition for Industrial Establishments the word "Fume" is used. If the words "Mist or Smoke" are considered to be fumes, then both intentions are the same. also, the stipulations stated in part (b) (ii), are covered by Section 73 (a & b) for Industrial Establishments.

One actual difference occurs when the Construction Projects Regulation names certain areas as being included as confined spaces, while no specific areas are named in the Regulation for

Industrial Establishments.

ATMOSPHERIC HAZARDS

Many potential hazards may be encountered by a worker during an entry to a confined space. Failure to recognize such hazards and take precautions may lead to property damage, injury, illness or even death. The ever present danger of asphyxiation, explosion or poisoning must be given due consideration in planning an entry to any confined space. Workers must have available and utilize appropriate protective equipment and proper work procedures. The rulefor anyone planning to enter a confined area is, "Never Trust Your Senses". What may look like a harmless situation may indeed be a potential threat. What may smell strange at first can impair the sense of smell and make you careless. Indeed, some of the deadliest gases and vapors have no odor at all.

Three of the most common atmospheric conditions that constitute hazards are:

1. Oxygen deficient or enriched atmospheres containing less than 18 % or more than 23% oxygen. Normal fresh air contains 20.9 % oxygen.
2. Combustible gases and vapourous atmospheres which may explode or ignite if a source of ignition is present in or introduced into the environment.
3. Toxic gases and vaporous atmospheres containing

contaminants that even in low concentration can cause serious injury or death. This category includes asphyxiants and irritants.

One should always anticipate that any one or a combination of the above atmospheric conditions might exist in tunnels, utility manholes, vaults, sewers, subcellars, excavations, railroad tank cars, sump pits, silos, open tanks, rooftop mechanical penthouses, cold storage facilities, ships' holds, stacks and chimneys, ductworks, brewers' vats, mine tunnels, abandoned wells, auto repair shops, sewage treatment plants and sanitary landfills. In addition, hazards sometimes appear unexpectedly in normal situations due to inappropriate industrial waste disposal or leakage of toxic substances into the surrounding earth strata or conduits.

Physiological and chemical hazards are often compounded by physical factors such as the tendency of gases lighter or heavier-than-air to pocket in irregular surfaces. Certain gases and chemical compounds have the potential to build up static electricity. Humidity, temperature and atmospheric pressure can also transform a normal environment into a hazardous one. If the environment in a manhole tests safe before the cover is removed, one should re-test the atmosphere after the natural flow of air has been disturbed by lifting the cover.

As the atmospheric hazards are discussed in greater depth, it should be remembered that caution must always be exercised, and that the unexpected can occur when operating in confined

space environments.

Oxygen Deficiency

Oxygen deficiency is probably the most common hazard found in a confined space. It is usually accompanied by combustible and toxic gas hazards.

Life ceases quickly without oxygen. Often the oxygen content in the air can become fatally low in a brief period of time. The particular danger of asphyxiation is the inability to detect and diagnose the problem. With an oxygen level below 16 percent a person begins to feel drowsy and is unable to think clearly. He will usually feel some slight difficulty in breathing and his ears may begin to ring. But none of these symptoms is likely to alarm him. More serious symptoms will follow. Euphoria (a false sense of well-being) develops and he is lulled into inactivity. If the concentration falls below 12 percent, he will rapidly lose consciousness and die.

Oxygen deficiency occurs in confined spaces where the level of oxygen has been reduced below the limit to support life. Some of the more common causes of this problem are oxidation of metals, bacterial action, combustion and displacement by other gases.

Slow oxidation of metals (rusting) is most prevalent in tanks made of iron or steel. These environments should always be tested for oxygen deficiency if work is to be conducted in them.

If ventilated, they may test safe, but once scaling starts the tank's atmospheric environment can change.

Sewage treatment plants, sanitary landfills, and sewer lines all contain enormous amounts of bacteria. Certain types of bacteria (aerobic) consume oxygen to produce carbon dioxide. Other types of bacteria decompose organic matter (anaerobic) and produce methane and hydrogen sulfide.

Carbon dioxide (CO_2) is widely used as a fire-extinguishing medium in refrigerated trucks and ships, and results as a by-product of fermentation and respiration. CO_2 is heavier than air and often forms pockets at the bottom of confined areas. It not only displaces oxygen but also causes an increase in the acidity of the blood. Concentrations as low as 6% CO_2 can be fatal in less than an hour.

Combustion is the rapid oxidation of a substance. It is a serious problem because fire rapidly consumes available oxygen. If sufficient ventilation has not been provided after a fire, the area may be dangerously low in oxygen long after a fire has been extinguished.

Oxygen deficiency may also be caused by gases that are physiologically inert (produce no effect on the body) when they exist in sufficient volume to exclude or displace an adequate oxygen supply. Among these are such substances as nitrogen. The use of nitrogen in inerting operations and its use as a medium for purging vessels can make it a deadly hazard.

When evaluating an area for potential oxygen deficiency, all of the above causes should be looked at closely before a determination is made.

Table (2-1) shows the possible effects of an oxygen deficient atmosphere on a medically fit individual at sea level.

TABLE 2-1

OXYGEN CONTENT	SYMPTOMS	EFFECTS
23 - 100%	None	Extreme risk of flammability. O_2 poisoning.
18 - 23%	None	None
12 - 16%	Increased pulse rate	Lack of "fine" co-ordination in fingers & hands
10 - 12%	Rapid pulse rate, nausea, headache	Breathing difficulties. Lack of co-ordination
6 - 10%	Acute lethargy	Complete lack of co-ordination. Inability to react to danger. Loss of consciousness
0 - 6%		Death

Combustible Gases

For a gas/air mixture to be combustible and an explosion or fire to occur; three components must be present simultaneously; fuel and air in the proper mixture, and a source of ignition such as a spark, fire or even a hot surface at a temperature higher than the ignition temperature of the gas or vapour. Figure (2-1)

illustrates the necessary components for a fire.

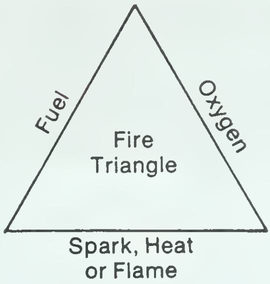


Figure 2-1

This proper mixture of fuel and oxygen varies from gas to gas, but in all cases is defined as an explosive range with a lower explosive limit (LEL) and an upper explosive limit (UEL). When the fuel and air mixture is below the lower explosive limit (lean mixture) ignition will not take place. In like fashion, if the fuel and air mixture is in excess of the upper explosive limit (rich mixture) ignition will not occur.

As an example, consider methane. Concentrations of less than 5% methane in air fall into the range below the lower explosive limit because the mixture does not have enough fuel (methane) to support combustion. i.e. the air-fuel mixture is too lean. If the methane concentrations exceeds 15% in air the air-fuel mixture is too rich for combustion and again ignition will not take place. Only when the methane concentration is between 5% (LEL) and 15% (UEL) does the potential for fire or explosion exist.

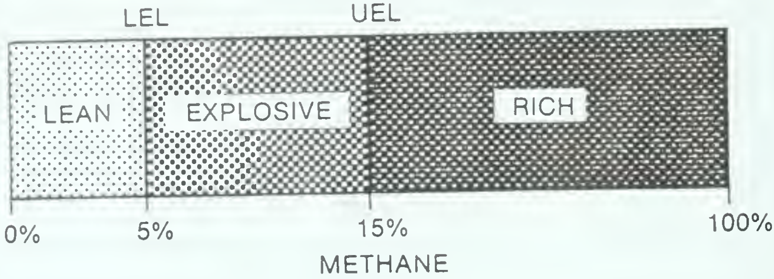


Figure 2-2

It is important to realize that when combustible gas or vapour concentrations rise above the UEL, the atmosphere still cannot be considered safe. This is because in some areas the rich gas may dissipate quickly and the concentration will drop into the explosive range between the LEL and the UEL.

Workers must be aware that the hazards resulting from gases can exist at any level. Differences in humidity, temperature and atmospheric pressure can cause the gases to become stratified within the confined space.

Combustible Vapours

When liquids are exposed to air, evaporation takes place. The amount of vapour formed by evaporation increases with the rise in temperature of the liquid. The flash point of a combustible liquid is the minimum temperature at which sufficient vapour has formed to make an ignitable mixture of vapour and air near the surface of the liquid. This means that the flash point

is the temperature at which the LEL of the vapour is exceeded at the surface of the liquid. Flash points vary greatly and as a result potential dangers vary greatly. As an example, kerosene normally has a flash point above 37.7 ^{o}C while aviation grade gasoline has a flash point of approximately -45.5 ^{o}C.

Many flammable gases and vapours are heavier than air. If they flow into a pit, tank opening or other confined spaces they will present a serious fire and explosion hazard. Disposal of flammable liquids into sewers present municipal workers with many potentially explosive situations. Gasoline vapours, cleaning fluid vapours, ether vapours, and natural gas are often found in sewage systems.

Toxic Atmospheres

Toxic substances are commonly found in industry and are generated by natural processes. Included as toxics are all gases and vapours that are known to produce disease, acute discomfort, bodily injury or death. There are two major classes of toxic gases that are found most often in confined spaces,

1. Asphyxiants, and
2. Irritants

Asphyxiants are gases which can cause asphyxiation by displacing the oxygen in the surrounding atmosphere. Those gases that are physiologically inert (produce no effect on the body) and are present in sufficient quantity to exclude an adequate

oxygen supply are called simple asphyxiants e.g. nitrogen, methane.

Substances which render the body incapable of utilizing an adequate oxygen supply are called chemical asphyxiants e.g. carbon monoxide. Carbon monoxide kills by chemically combining with the hemoglobin in the red blood cells. This greatly reduces the ability of the blood to carry oxygen to the body tissues and brain. Death occurs due to chemical asphyxiation.

Carbon monoxide (CO) is one of the most common asphyxiants encountered. It is formed by incomplete combustion whenever fuel containing carbon is burned. In addition to its being a by-product of many industrial operations, it is produced in large amounts by internal combustion engines such as automobiles, fuel powered compressors, generators and fork lifts.

Irritants are gases that in vary low concentrations, are mildly irritating to the respiratory and nervous systems. At higher levels, they cause death. (e.g. hydrogen sulfide, chlorine).

Hydrogen sulfide (H_2S) is even more toxic than carbon monoxide. Air containing as little as 100 parts per million (ppm) or 0.01% H_2S may cause death in a few hours. Death is due to asphyxiation resulting from paralysis of the muscles which control breathing. In low concentrations it is classified as an irritant because it inflames the mucus membranes and results in the lungs filling with fluid (pulmonary edema, also known as

chemical pneumonia). The colourless gas has a characteristic rotten egg odour. Since the gas renders the olfactory nerve (which controls the sense of smell) ineffective (a condition referred to as Olfactory Fatigue), a worker may be lulled into a false sense of security not realizing that a toxic concentration of the gas may be present.

Hydrogen sulfide is a hazard in many industries not only because of its use in manufacturing, but also because of its accidental occurrence. It is recognized as a major hazard in the oil refining industry, in sewage treatment and wherever organic matter containing sulfur decomposes.

Toxic gases and vapours also have other special characteristics and properties that the confined space worker must be aware of. The Threshold Limit Value - Time Weighted Average (T.L.V. - T.W.A.) is the time weighted average concentration of airborne concentrations of substances which a worker may be exposed to for a normal 8 hour workday in a 40 hour work week, without adverse effect.

TABLE 2-2 Gas Characteristics

Gas	Physical Characteristics	Flammability Lower & Upper Explosive Limits (LEL) (UEL) % Volume	Toxicity Threshold Limit Values (T.L.V.s) % Volume
Carbon Monoxide CO	colourless odourless	12.5% to 70%	0.005%
Carbon Dioxide CO_2	colourless odourless	Non-Flammable	0.5%
Methane CH_4	colourless odourless	5% to 15%	0.001%
Hydrogen Sulfide H_2S	colourless rotten egg odour *	4.3% to 46%	0.001%
Sulphur Dioxide SO_2	colourless suffocating odour	Non-Flammable	0.005%
Nitrogen Dioxide NO_2	brown pungent odour	Non-Flammable	0.005%

* At high lethal concentrations, it cannot be smelled due to paralyzing action on the olfactory system.

Summary

In summary, when entering a confined space assume that there may be an atmosphere with an oxygen deficiency, combustible gases and/or toxic substances. In order to prevent immediate or cumulative bodily injury or a threat to life, each atmosphere should be tested for those dangers before entering.

If combustible or toxic gases exist in a confine space any entry procedures must include the provision of adequate forced air ventilation. The ventilation air should not create an additional hazard due to recirculation of contaminants, improper arrangement of the inlet ducts, or by substitution of any other than fresh normal air. Do not use oxygen as this will expand the flammability limits and increase the hazards of fire and explosion.

Table 2-2 depicts the characteristics of the most common gases found in confined spaces.

CHARACTERISTICS OF COMBUSTIBLE AND TOXIC GASES

It is necessary that the confined space worker be familiar with the hazards of the dangerous gases that he may be in contact with. The following descriptions briefly describe the common dangerous gases.

Methane

Keep below explosive limits. Methane is a flammable gas. It acts as a simple asphyxiant, suffocating an individual by displacing the oxygen necessary to sustain life. It is lighter than air and is usually found at the top of a confined space.

Other Common Names

Marsh gas, methyl hydrate, hydride, gas, methyl, marsh

General Properties

Colour -	Colourless
Flammability -	Flammable
Explosive Limits -	5.3% to 14% by volume in air
Odour -	Odourless
Relative Density -	0.5549 at 16 degrees C
Corrosivity -	Non-corrosive
Use -	Testing of gas appliances, calibration of instruments

Hazards to Life

On exposure to fire is no more hazardous than an ordinary combustible. May displace air for breathing, causing suffocation. Can detonate or explode under a strong igniting source, or after contacting water and heating under confinement. Can be ignited at almost all temperatures. Maximum allowable concentration by volume in air - 1000 ppm per 8 hour day.

Degree of Risk

Flammable material. Non-toxic but displaces oxygen for breathing.

Hydrogen Sulfide

T.L.V. 14 mg/m^3 (10 ppm)

This is a toxic flammable and highly explosive gas which is approximately 0.25 (1/4) times heavier than air. It tends to settle at the bottom of an area. If however, intermittent or restricted air flow in an upward direction occurs, the hydrogen sulfide can be lifted and form a layer which will contaminate the area above the bottom of the confined space. In addition, where conditions of high temperatures and high humidity are present (which can occur during the summer months) the hydrogen sulfide can be lifted to the upper areas of the confined space.

Hydrogen sulfide is an irritant with a very strong and offensive odour which on the first inhalations is similar to that of rotten eggs. Smell cannot be considered a reliable source of warning since 3 ppm has a numbing effect on the sense of smell, so that a strong concentration of the gas will not be detected by a person in the area.

In addition to its lethal qualities, hydrogen sulfide is extremely flammable and highly explosive. The explosive range for hydrogen sulfide is from 4.3% to 46% by volume in air. When compared to methane, hydrogen sulfide will explode at a lower percentage than methane, and its explosive range is three times greater.

Exposure to concentrations of hydrogen sulfide, even those concentrations below the recommended TLV (Threshold Limit Value)

of 14 mg/m^3 (10 ppm) can have a serious effect, and even fatal consequences. After exposure, the victim may appear to make a complete recovery, but it is not uncommon for a relapse to occur 2 or even 3 days later. When such a relapse occurs, a pulmonary edema or heart attack results which can cause death.

Other Common Names

Sulfurated hydrogen, hydro-sulphic acid, sulfide, hydrogen, sulfurated acid, hydro-sulfuric.

General Properties

Colour -	Colourless at low concentrations Greenish yellow otherwise
Flammability -	Highly flammable
Explosive Limits -	4.3% to 46% by volume
Odour -	Offensive (rotten eggs) at low concentrations. Odourless otherwise
Vapour Density -	1.189
Relative Gravity -	1.54

Hazards to Life

Short exposure can seriously injure, even if treated promptly. Acute effects are not cumulative in action. Exposure to moderate concentrations causes headaches, dizziness, nausea, vomiting. Continued exposure may cause loss of consciousness, respiratory failure and death, if gas concentration is sufficiently high. At high concentrations loss of consciousness

is rapidly followed by respiratory failure in a few minutes. Permanent and severe brain damage could occur. Significant exposures may result in the complete and permanent loss of smell.

Chronic Effects

Low concentrations irritate the mucus membranes, eyes and respiratory tract. Eye effects have been reported at 20 ppm or less.

Breathing

Use a self contained breathing apparatus where exposure is irritating at any concentration.

Degree of Risk

Danger - Serious, severe, extremely hazardous. Toxic Material - Can injure through touch or breathing. Flammable Material. Greatest danger is from acute effects. Fatal in breaths if concentration in air is greater than 700 ppm. At normal temperatures and pressures will vapourize rapidly and burn easily. Burns in air forming sulphur dioxide. At concentrations of 4.3% to 46% by volume in air, explodes upon ignition. Mixture of 2 parts hydrogen sulfide and 3 parts oxygen, explodes violently upon ignition. Vapours are heavier than air and may travel considerable distance to a source of ignition and flash back.

Carbon Monoxide:

T.L.V. 40 mg/m^3 (35 ppm)

Carbon monoxide is colourless, odourless and tasteless. It is classified as a chemical asphyxiant which can kill since it combines with the hemoglobin of the blood, preventing the red blood cells from absorbing oxygen and transferring it to the body tissues. It is lighter than air so it is found near the top or the surface of a confined space. The explosive range of carbon monoxide is from 12.5% to 70% by volume in air.

Carbon Dioxide:

T.L.V. 900 mg/m^3 (5000 ppm)

Carbon dioxide is a colourless, odourless gas which acts as a simple asphyxiant, causing suffocation by displacing oxygen from the lungs. The symptoms are headache, dizziness, shortness of breath, muscular weakness, drowsiness and ringing in the ears. Remove victim from exposure, rest, keep warm; seek medical aid in severe cases.

Sulphur Dioxide:

T.L.V. 13 mg/m^3 (5 ppm)

Sulphur dioxide is a colourless gas with a strong suffocating odour. Exposure in high concentrations may cause reddened, swollen eyelids, blinding damage to the eye coverings, loss of sense of smell, pain and irritation in the nose and throat, chest pain, cough, shortness of breath, difficulty

breathing, chemical pneumonia, cyanosis (lips, fingertips, ears turning blue), fluid build-up in the lungs, nausea, vomiting, fatigue and skin burns. Death may occur due to paralysis of the respiratory system.

Remove worker from the exposure immediately and seek medical aid. Be prepared to administer oxygen and artificial respiration.

Nitrogen Dioxide:

T.L.V. 310 mg/m^3 (100 ppm)

Nitrogen dioxide is a reddish-brown gas or a yellow liquid which becomes colourless at 11.2 ^{o}C. Exposure is very dangerous as it can enter the respiratory tract with only minor irritation to the nose or throat. When in the lungs, however, it combines with water to form highly irritant acids and alkalies. Therefore, a transient period of burning in the nose and throat may be followed by six to twenty-four hours of symptom-free time. Then tightness and burning in the chest may develop, followed by shortness of breath, sleeplessness and restlessness. Difficult breathing and air hunger develop rapidly, followed by cyanosis (lips, fingertips and ears turning blue), loss of consciousness and death. Concentrations of 100-150 parts per million are dangerous for short exposures of thirty to sixty minutes. Concentrations of 200 to 500 parts per million may be fatal after even very short exposures. Daily exposure to lower concentration may cause coughing, headache, loss of appetite, stomach upsets, corrosion of the teeth and gradual loss of strength.

Remove worker from the exposure, rest, keep warm; seek medical aid for severe cases.

There are many other gases and vapours that may be present within the confined space at any given time that will require the worker to observe any safety guidelines set out for them.

PHYSICAL HAZARDS OF CONFINED SPACES

In addition to the atmospheric hazards previously mentioned a number of physical hazards exist in confined spaces. They are listed as follows:

a) Physical injuries
b) Body infection
c) Excessive noise levels
d) Insects and vermin
e) Ionizing and electromagnetic radiation
f) Fire and explosion
g) Electric shock
h) Mechanical hazards, e.g. operation of process equipment
i) Extremes of temperature and humidity or contact with hot objects
j) Drowning

Because of moisture, condensation, slime growths or deposits of other materials, the danger of slipping and falling is high. Deterioration of structures, rusting of ladder rungs, grating and

railings, can result in falls and head injuries. The worker may also be exposed to pathogenic diseases, such as Tetanus, Typhoid, Cholera, Diptheria, Polio, and dysentery. The possible presence of rats and other vermin is also a potential danger. Improper handling of tools and equipment can result in cuts, bruises and back injuries.

Since many of the areas in which work may be done are quite small, head protection and protective gloves should be worn when using hand tools and the footing should be secure to avoid back injuries, slips, trips or falls. Workers at the surface must ensure that the vicinity of the access is kept free of all objects which might fall into the confined space.

For protection against heat and cold, proper attire and when necessary, "warm-up or cooler breaks" should be considered.

CONFINED SPACES IN THE WORK ENVIRONMENT

Table 2-3 identifies some of the more common areas in the work environment that are confined spaces. The areas listed are not to be considered as a complete list. Other areas which, while not shown, are still confined spaces. The listing of areas has been customized to those commonly found in wastewater and water treatment facilities, industrial and rural areas.

SUMMARY

1. Confined spaces may be encountered as a routine part of the work environment.
2. Confined spaces can be below grade, at or above grade and can be any size or configuration.
3. Confined spaces can contain an oxygen deficient atmosphere (below 18%), an oxygen enriched atmosphere (above 23%), an explosive atmosphere, a toxic atmosphere or a combination of all.
4. Physical hazards are present during the entry or exit of a confined space as well as working in the space.

TABLE 2-3 <u>Confined Spaces</u>

1. Digesters
2. Sludge Holding Tanks
3. Covered Aeration Cells
4. Sewer Manholes
5. Valve Chambers
6. Wet Wells
7. Storm Sewers
8. Chemical Storage Tanks
9. Meter Chambers
10. Scum Pits
11. Clarifiers
12. Splitter Boxes
13. Enclosed Filter Tanks
14. Reservoirs
15. Elevated Water Storage Tanks
16. Sump pump chambers
17. Clear Wells
18. Water Well Pits
19. Electrical Manholes
20. Industrial Furnace Interiors
21. Dust Collectors (Bag Houses)
22. Fluidized Bed Reactors
23. Industrial Boiler Interiors
24. Industrial Pressure Vessels
25. Structures on Landfill Sites
26. Cisterns
27. Septic Tanks
28. Enclosed Crawl Spaces
29. Silos

SUBJECT:

CONFINED SPACE ENTRY WORKSHOP

TOPIC: 3

Atmospheric Sensing and Detection Equipment

OBJECTIVES:

The Trainee must be able to:

1. List four types of direct reading instrumentation.

2. Explain the two methods of exposing a sensing device to an atmosphere.

3. Identify the advantages and disadvantages of sample draw and diffusion detection instrumentation.

4. Identify the principles of operation for:

    a) Catalytic sensors
    b) Semi-conductor sensors
    c) Electrochemical sensors
    d) Colourimetric analyzers

ATMOSPHERIC SENSING

GENERAL

Potentially dangerous concentrations of flammable or toxic gases and vapours can occur and/or accumulate in many different locations. Where entry to such an area is necessary, it is essential to be able to determine whether any harmful gas is present and whether its concentration is such that it becomes a health and/or an explosion hazard. Such detection and measurement of concentration levels must be carried out using precise techniques and instrumentation.

It should be recognized that no single device or technique is the perfect solution for all applications. The principles of detection must be fully understood by the user so that correct determinations can be made.

DETECTION & MEASUREMENT INSTRUMENTATION

Gas detection and measurement instrumentation falls into two categories; direct reading and indirect reading. Indirect reading of toxic and combustible gases is performed by taking a sample of the atmosphere to be tested to a location containing the instrument that will perform the analysis. For confined space workers, this type of detection is unacceptable due to the fact that only one grab sample of an atmosphere can be tested and great amounts of time are wasted by traveling to and from the testing facility.

Direct reading instruments offer the confined space worker many distinct advantages. They not only provide an immediate readout of atmospheric hazard levels but can also continuously record these levels, provide alarms, and activate controls to correct the situation (open doors, turn on ventilation, shut down a process, etc). Direct reading instruments can be classified into four main types.

1. Analyzers - These instruments provide a visual readout only.
2. Monitors - Audible and/or visual alarms warn personnel of an atmospheric hazard. Outputs are often provided for auxiliary alarms or equipment operation.
3. Recorders - They provide a permanent record of hazard levels. Recorder outputs are often an option with analyzers or monitors.
4. Dosimeters - When chronically toxic substances are being measured, it is often necessary to know the time weighted average (TWA). A dosimeter automatically calculates the time weighted average.

In all four types of instruments there are two methods of exposing the sensing device to the atmosphere -

1. Sample draw, and
2. Diffusion

In sample draw instruments, the atmosphere is pulled into the device by using either a hand aspirator or a pump. In diffusion instruments, the sample reaches the sensor by air movement.

The primary advantage of sample drawing is that the sensor is housed inside the instrument - a sheltered environment. The disadvantages include:

1. Sample dilution - Any leak in the sampling system will cause an erroneous low reading.
2. A lag in instrument response time - The transport time through the sampling line can become significant when the distance between the atmosphere and the sensor is increased. Allow 3 seconds of response time for every metre of sampling line.
3. Sample draw system failure - Pumps are chronically troublesome. Unless a flow alarm is incorporated in the system, the user is not normally aware that his instrument is malfunctioning.
4. Long sample lines are very cumbersome and inconvenient.
5. If the sample draw system is used in a cold environment, a sample from a warmer area could condense or even freeze in the line. If a combustible vapor is being measured, a decrease in temperature

may cause the vapour to condense below its flashpoint, giving a false indication of safety.

6. Many flammable or toxic substances can be absorbed by the sampling line, giving an erroneous low reading.

The advantages of diffusion sensing include:

1. No pumps or moving parts are required.
2. The sensor can be placed in the monitored environment.
3. In remote locations, it is normally easier to run wires than a sampling line.

Some of the disadvantages include:

1. Some sensing techniques require a continuous sample flow. The electrochemical toxic gas sensor is an example.
2. For atmospheres at very high or low temperatures, with excessive moisture, particulate matter, or with high air turbulence, a sample draw method should be used for accurate readings.
3. Limited access areas pose another problem. Diffusion head sensors don't readily fit through manhole covers.

There are some instruments which utilize the best features of both sample draw and diffusion techniques. With the use of a sample draw kit, the atmosphere in the confined space can be tested before making an entry. When the sample has been drawn, the kit is removed and the atmosphere contacts the sensors by natural air movement; no additional operator involvement is required.

Once the measuring and sampling techniques have been selected, it is necessary to determine whether spot or continuous sampling is required. If it is likely that atmospheric conditions will not change once personnel have entered an area, one-time sampling with a portable device is adequate. If conditions change however, or if a person is working in an atmosphere where the unexpected appearance of a hazard is possible, a continuous monitor with alarms is a better solution.

PRINCIPLES OF OPERATION

Combustible Gases & Vapours

Several techniques exist for measuring concentration of combustible gases in the air. They include the following:

1. Thermal Conductivity Devices. Air is pumped across a heated element and if a gas other than air is present the element gives off heat at a different rate than for pure air. The electronics of this type

of instrument sense the change of temperature and provide a meter indication.

2. Semiconductor Sensors. These devices utilize an electrical resistance change of the semiconductor material when the gas of interest is absorbed on its surface.

3. Photometric Devices. These instruments measure the amount of light energy absorbed in a gas sample.

4. Optical Refractive Index Devices. These instruments work on the principle that different gases refract light at different angles.

5. Catalytic Devices. This is the most widely used method for determining the presence of combustible gases and vapours. When certain metals such as paladium and platinum are heated and exposed to combustible gas/air mixtures in concentrations below the flammable region, the mixture will burn near the surface of the metals. Paladium and platinum act as a catalyst, enabling this combustion to occur even at very low gas concentrations.

In some instruments the catalyst metal takes the form of a wound filament connected to a Wheatstone Bridge Circuit (Figure 3-1).

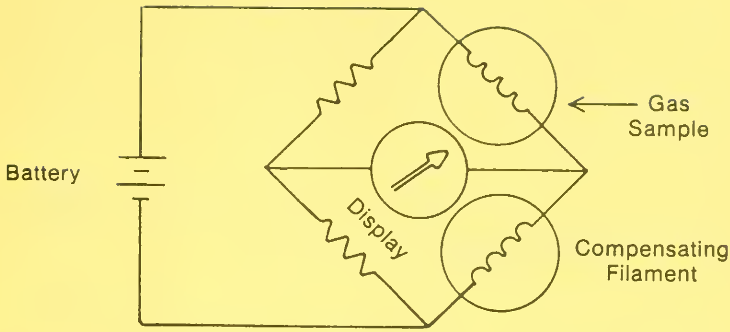


Figure 3-1 Wheatstone Bridge Circuit

The circuit uses the principal that a wire's electrical resistance is increased with increasing temperature. The filament is heated by a controlled electrical current. In the presence of a flammable gas the catalytic filament burns the gas, increases in temperature, and increases in electrical resistance. This causes an electrical signal to be displayed on the meter. If the meter is calibrated from 0 to 100 percent LEL, as the gas concentration is increased the meter output will accurately indicate the gas level.

A recent improvement on this technique involves a sensing element redesign. The filament is coated with a ceramic bead upon which a catalyst (paladium or platinum) is deposited. This modification allows operation at a lower temperature, increasing sensor stability and life. The temperature-compensating bead is physically identical to the sensing bead but is not catalytically treated and is not sensitive to combustible gas. If this bead were not used the instrument would be very temperature sensitive.

The flame arrester in the sensor unit prevents propagation of a flame outside the filament chamber if the instrument is used in an environment containing more than 100% LEL gas.

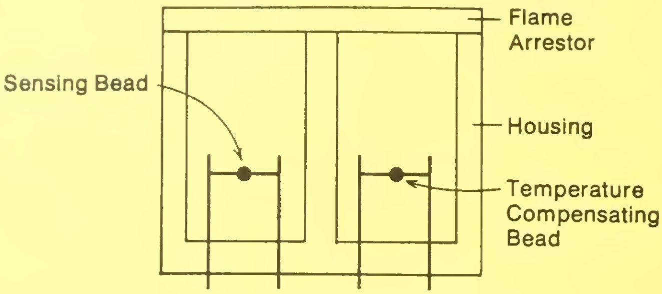


Figure 3-2 Combustible Gas Sensor

This technique is sensitive to all combustible gases and vapours. To determine the explosive concentration of a variety of different gases and vapours, calibration curves are available from the manufacturers correlating meter readings to individual gases.

Instruments utilizing hot wire or catalytic element detectors will respond only to those combustibles drawn through the sampling system and in direct contact with the detector filament or element. If the flash point of a material is higher than the normal ambient temperature, a relatively low concentration will be indicated by the instrument.

These types of detectors are not appropriate for measuring combustibles in steam or inert atmospheres because of the reduced concentration or absence of oxygen. Oxygen is necessary to

support combustion on the filament or element.

Toxic Contaminants

There are three common ways to measure toxic levels of gases, vapors, dusts and mists in the atmosphere.

1. Direct reading instrumentation.
2. Chemical methods.
3. Mechanical methods.

Direct reading devices utilize a wide variety of techniques. They include:

1. Chemical colourimetric devices. A sample of gas to be tested is passed through an adsorbing media which is chemically treated to react to the vapour or gas being analyzed. On contact, a colour stain is produced, the length of which will vary according to the concentration of the gas or vapour being tested. A measured sample is drawn through a calibrated tube and the length of the stain is read against the scale printed on each tube.
2. Photometric devices. These instruments measure the amount of light energy absorbed in a gas sample.
3. Ionization devices. These instruments generate ions (electrically charged atoms or

molecules) by techniques including burning the gas sample in a hydrogen flow, exposure to light of certain frequencies, or exposure radioactive material.

4. Catalytic devices. The detection principle is the measurement of heat produced by chemical reactions on catalytic surfaces or in granular catalytic beads.

5. Semiconductor sensors. An oxidation reaction occurs on the surface of the semiconductor sensor when a toxic or combustible gas is present. This reaction changes the sensor's electrical resistance. The sensor acts as a variable resistor which responds to a change in gas concentrations. When the hazardous gas level exceeds a certain concentration, the alarm circuitry of the instrument is activated. Semiconductor sensors can become contaminated by exposure to heavy concentrations of industrial vapours, smoke, fumes from an open gas flame or lacquer vapours. Contaminated sensors will give erroneous indications and therefore require cleaning before they can be utilized. The usual method of decontamination is to apply heat to the semiconductor until contaminating agents have been burned off or purged away.

6. Electrochemical devices. When the gas

sample comes in contact with the chemical sensor, an electrical phenomenon is caused by the oxidation of toxic gas at a potential controlled electrode. The basic components of the instrument are an electrochemical sensor, a sampling pump, and an electronic control and measuring circuit. The sensor consists of a sensing electrode, a counter electrode, a housing containing an acid electrolyte and a Teflon membrane which is porous to gas but non-porous to liquid. The membrane allows the gas to diffuse into the reaction site while containing the acid solution.

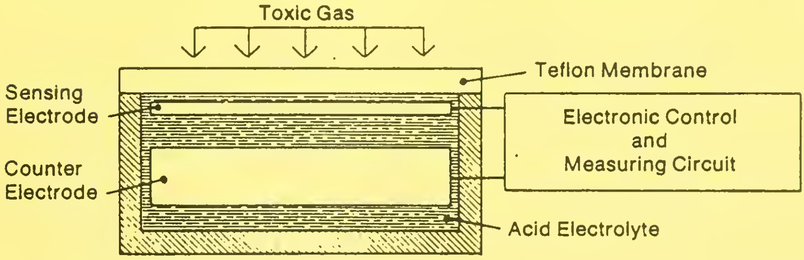


Figure 3-3 TOXIC GAS SENSOR

Gas molecules come in contact with the acid solution at the sensing electrode. The electrochemical oxidation of the toxic gas at the reaction site generates a current. The current flows between the sensing and counter electrodes. The current is directly proportional to the concentration of the gas and the

concentration is displayed at the meter.

As mentioned previously, in addition to direct reading instruments there are two other common methods for determining toxic gas levels. The first of these is the chemical process of colourimetric indicating tube generally used with gases and vapours. There are tubes available for instantaneous reading when used in conjunction with a hand-aspirated pump and for time weighted average readings when used with a continuous sampling pump. Colourimetric tubes are widely used; however, the tubes are impossible to use in an alarm system.

Another chemical method of evaluation is the collecting of samples in containers, or adsorption on charcoal. These samples are then sent to a laboratory for further chemical determination.

Mechanical methods of toxic atmosphere evaluation generally involve analysis of dusts and particulates. The dust and particulates are collected in a filter medium by drawing the air with a sample pump of a known flow rate. The collected matter is then weighted. Filters for this method are usually made of paper or glass fibers.

Because there are many ways to test for toxic atmospheres, careful analysis of the alternatives should be considered before a selection is made.

Oxygen Deficiency

Measuring the amount of oxygen in the air of working environments is generally done by means of an instrument containing an electrochemical sensor. The sensor consists of a sensing electrode, a counter electrode, a housing containing a basic electrolyte and a Teflon membrane. The oxygen molecules diffuse through the membrane into the sensor. Electrochemical reactions at the two electrodes produce an electron flow. This minute current, which is directly proportional to the oxygen level seen by the sensor, passes through a temperature-compensating electronic circuit. The resulting voltage activates a meter display which is usually calibrated in percentage of oxygen.

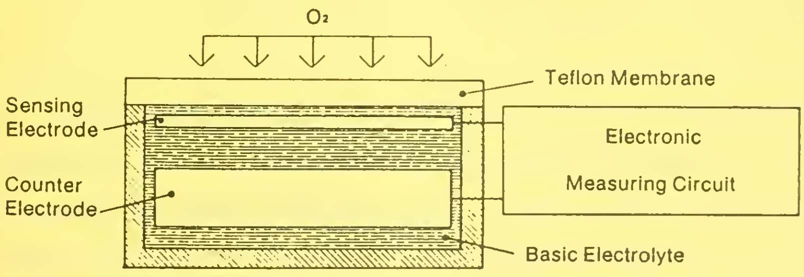


Figure 3-4

The chemical action in the sensor's cell goes on continually whether the instrument is in use or not and eventually (three to twelve months) the cell depletes and must be replaced. A depleted cell will not respond to calibration attempts and will cause an instrument to alarm continuously.

SAFETY CONSIDERATIONS

Where combustible gases or vapours are routinely present or may be present accidentally, special safety precautions must be taken. All equipment must be either intrinsically safe (low-energy devices which do not release sufficient energy to cause an explosion even in the event of an instrument malfunction) or, mounted inside an approved heavy-duty explosion-proof enclosure. Equipment must be non-incendive (incapable of releasing sufficient energy for ignition during normal operation).

As an example, a portable combustible gas detector with rechargeable batteries which may be intrinsically safe should not be operated with the battery charger connected. The battery charger might provide sufficient energy for ignition of a flammable mixture in the event of a malfunction.

Sensor and instrument location is extremely important. To locate the sensor for continuous monitoring it is often wise to perform a spot-check survey with a portable analyzer. Sensor or sampling line location can be determined with the results and several other considerations:

1. Sensor placement should be low for gases heavier than air and high for gases lighter than air. Consideration of air currents is necessary.

2. Sensors should be located near potential hazards such as pumps, pressure relief valves, solvent storage containers and stacks.
3. If sample lines are used, line length, possibility of condensation of particulate contamination, and the instrument response to flow and pressure variations must be considered.

Atmospheric instrumentation requires routine maintenance. The most important maintenance item is frequent calibration. Check calibration before each day's use. In fresh air, check and calibrate instruments monthly. This check normally involves exposing the sensor to a known gas concentration and observing or correcting the instrument responses. Generally, the expense and inconvenience of calibration checking are minimal compared to the added safety. Sample lines should be tested for leakage. If an automatic sample draw pump is used it should be provided with a flow alarm. If filters are used in an instrument they should be checked, cleaned and changed if necessary.

Toxic & Combustible Gas Monitors

1. Make sure that batteries are fully charged at or near rated voltage.
2. Calibrate the instrument according to the manufacturer's instructions.
3. Allow sufficient time for temperature

compensation for the environment under test.

Do not:

a) immerse sensor heads directly in liquids or particulates.

b) make gas measurements in fast moving air currents; high air flow rate can act to cool a sensor element and interfere with a true gas signal.

c) leave sensors exposed to gross toxic gas environments for relatively long periods of time as degradation of the sensor element will occur.

<u>Colourimetric Analyzers</u>

1. Break tips off fresh detector tube by bending each tube end in the tube tip breaker on the pump.
2. Insert the tube securely into the pump inlet with arrow on tube pointing towards the pump.
3. Use the pump to draw the desired volume of sample through the tube.
4. Read concentrations at the interface of stained-to-unstained reagent when staining stops.

SUMMARY

1. Potentially dangerous atmospheres may develop in certain work locations and present a health or explosion hazard to an unsuspecting worker.
2. A worker's senses are inadequate or unreliable, as detectors. Proven techniques and appropriate instrumentation must be employed to detect hazardous atmospheres and alert workers to potential danger.
3. The principles of detection must be fully understood by the user of gas detection equipment so that correct determinations can be made.
4. Only by following the manufacturer's instructions carefully and by practicing frequently can workers become competent and produce reliable results with gas detection devices.

SUBJECT:

CONFINED SPACE ENTRY WORKSHOP

TOPIC: 4

Protective Equipment

OBJECTIVES:

The Trainee will be able to:

1. List examples of personal and general protective equipment.
2. Recall noise level exposure requirements for hearing protection.
3. Identify the operating principles and limitations for respiratory protective devices.
4. Name 5 pathogenic diseases.
5. Describe effective methods of personal hygiene.

PROTECTIVE EQUIPMENT

GENERAL

The subject of protective equipment can easily be divided into two categories.

1. Personal Protective Equipment
2. General Protective Equipment

Personal protective equipment refers to the hard hat or safety boots required to be worn by all confined space workers. An example of general protective equipment is the ladder used by the worker when entering a well or manhole.

It quickly becomes obvious that certain pieces of equipment could easily be in both categories. The particular use at a given time will dictate in which category the equipment should be considered. For example, a toxic gas monitor worn on a workers belt is a piece of personal protective equipment but that same monitor when attached to a wall of a confined space would be considered a piece of general protective equipment.

The hazards that exist in confined spaces have been minimized as much as possible by incorporating such features as explosion proof switches, ventilation fans, and enclosed energized electrical panels. For the most part the hazard protection has been built in, however there are many hazards for which protection cannot be built in. These hazards involve

workers personally on the job and in the work environment.

A recent study carried out showed that one out of every eight injuries (approx. 12%) was attributable to workers failing to wear the personal protective equipment required for the given task. The only sure way to reduce the odds of being injured is to wear and use the proper protective equipment.

PERSONAL PROTECTIVE EQUIPMENT

Head Protection

A Canadian Standards Association (C.S.A.) approved hard hat is necessary for any worker who is exposed to the hazard of head injury. The hard hat is usually mandatory, when working on construction projects; below grade; under elevated areas; in areas of low overhead obstacles; and in confined spaces.

Hard hats must be replaced upon visible discovery of damage regardless of use. Head strapping in the hard hat should be replaced when found unsatisfactory. Hard hats should not be worn by more than one person and should be kept from exposure to direct sunlight. There is no longer any mandatory replacement time limit for hardhats. If the hat is in good condition it is considered to still be functional.

A common practice is to apply stickers to hardhats for a personalized appearance. Unknowingly, workers who follow this practice are causing premature failure of the hardhat due to

chemical reactions between the hardhat and the sticker adhesives. Approved stickers are available and should be the only ones on the hardhat.

Eye Protection

Where a worker is exposed to potential eye injury from;

1. flying particles,
2. hot, corrosive or poisonous substances,
3. harmful light or other radiation, or
4. other substances.

The worker should be protected by a screen, face shield, safety glasses or eye shield or any other suitable device appropriate in the circumstance.

All eye protection devices must be consistent with the requirements of the Canadian Standards Association (C.S.A.) for the particular exposure hazard.

The use of spectacles or safety goggles in confined spaces may be difficult because of their tendency to fog. The glasses also can become smeared by moisture in the confined space environment, thus resulting in decreased vision capacity by the wearer. Proper ventilation will reduce fogging problems. If a chipping gun or other tool is being used to chip concrete or pipe, safety glasses or goggles must be worn. A clear face shield may be better than safety goggles.

Hearing Protection

In areas deemed to be a noise hazard that is with a sound level above 90 dBA approved hearing protection should be worn. The Occupational Health & Safety Act provides an exposure table (Table 4-1) which outlines the maximum exposure time allowed to an indicated sound level without hearing protection. When the exposure to the noise levels exceed the table values, hearing protection must be worn.

Table 4-1 Noise Level Exposure

Sound Level - in Decibels	Duration - Hours per 24 hour Day
90	8
92	6
95	4
97	3
100	2
102	1.5
105	1
110	0.5
115	< 0.25
Over 115	No exposure

Approved hearing protection means sufficient protection that will attenuate or reduce the sound to levels that would correspond with the allowable exposure time.

Various methods are incorporated in providing hearing protection to workers and could include the following:

1. Soundproofing
2. Muff type ear protection (Figure 4-1)
3. Plug type ear protection (Figure 4-2)

Figure 4-1

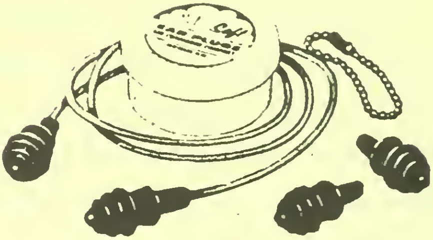


Figure 4-2

Respiratory Protection

Respiratory protection must be used when a situation exists that would expose the worker to:

1. Dusts, vapours & mists.
2. Toxic atmospheres.
3. Oxygen deficiency, and
4. Unknown hazards.

The equipment necessary to protect the individual's respiratory system from hazards can be divided into 3 different categories based upon intended use and hazard type. These categories are:

1. Purifying Filters.
2. Self Contained Breathing Apparatus (S.C.B.A.)
3. Air line respirators.

Purifying Filters

Purifying filters are devices that incorporate a nose piece or full face mask in which the wearer breathes purified air after it has passed through a filter medium. The filters can be a simple dust mask or an adsorbtion column. Also filters can be made from paper, fibreglass and activated carbon or any combination of the three materials. These filter type respirators include dust masks, surgical masks, cartridge and canister type respirators.

Purifying filters are accepted respiratory protection only when the concentrations of the atmospheric contaminants are low and only when the correct filter is used for the correct contaminant.

The use of purifying filters in confined spaces is not recommended because:

1. Purifying filters don't supply oxygen to the wearer in oxygen deficient atmospheres.

2. Concentrations of gases, vapours and mists may exceed the filters rating as the work progresses in the confined space.
3. Purifying filters don't normally indicate when the filter isn't working properly or when The cartridge or canister is spent.

Self Contained Breathing Apparatus (S.C.B.A.)

Self contained breathing apparatus is a respirator system where a supply or a means of respirable air, oxygen or oxygen generating material is carried by the wearer. Normally self contained systems are equipped with a full facepiece. S.C.B.A.'s can be divided into two types:

1. Open Circuit, and
2. Closed Circuit.

In the open circuit type exhalation air from self contained breathing apparatus is vented externally and not reused. Open circuit, self contained systems are generally simple to operate and require very little after use maintenance. Open circuit systems can further be divided into two configurations:

1. Demand, and
2. Positive Pressure (Pressure demand)

The demand configuration utilizes compressed breathing air. This air has been filtered to ensure that there is no water, oil

or carbon monoxide contained within it. Air under high pressure (2250 psi to 4500 psi) is stored in a cylinder on the users back. When the user demands air, the vacuum created at the face mask is transmitted via a series of springs and diaphragms to a pressure regulator/reducing valve. The valve is opened by the vacuum and breathing air enters the face mask as long as inhalation continues. This happens instantaneously and the wearer hardly notices (except for the sound) what has gone on. When the user exhales the air is exhausted through a one way valve to atmosphere.

The positive pressure configuration is similar in operation to the demand system. The only difference is that a slightly higher than atmospheric pressure is maintained in the face mask so that in the event of a leak, air will continue to flow through the leak and protect the user from breathing in the contaminated atmosphere.

Although the demand and positive pressure systems are available in 4, 15, 30 and 60 minute models, actual breathing time is not absolute. Variations in temperature, pressure, individual experience and activity level make the rated numbers only approximations.

During operation the eventual lowered pressure in the cylinder will activate a bell that indicates that there is approximately 5 min. of air left to consume. This is a warning device only, the actual amount of air in the cylinder will be confirmed by the pressure gauge. A good rule of thumb is to get

to a safe area before the pressure gauge reads 500 psi.

Closed circuit S.C.B.A.'s also can be segregated into 2 groups:

1. Oxygen Supplied, and
2. Oxygen Generating.

These devices normally use an oxygen supply or oxygen-generating material which enables the wearer to re-breathe his exhaled "air" after the carbon dioxide content has been effectively removed and a suitable oxygen concentration is restored. A closed circuit unit generally provides longer breathing duration. Close circuit systems are used extensively in long duration operations such as mine rescue. Once properly trained a user can breath and work in contaminated atmospheres for up to 5 hours.

Closed circuit systems are lightweight and compact but have to be serviced after each use.

Air Line Respirators

Air line systems are open circuit devices that utilize a larger capacity of breathing air located outside of the confined space (Figure 4-3). The worker is connected to the air line and must trail the air line like an umbilical cord behind him. Care must be taken by the worker not to snag the air line and cut off the air supply. Also the mask could be pulled away from the

worker if the airline was suddenly snagged. Air line systems can be operated using a full face mask or a nosepiece breathing attachment. A full face mask is necessary for confined space operations.

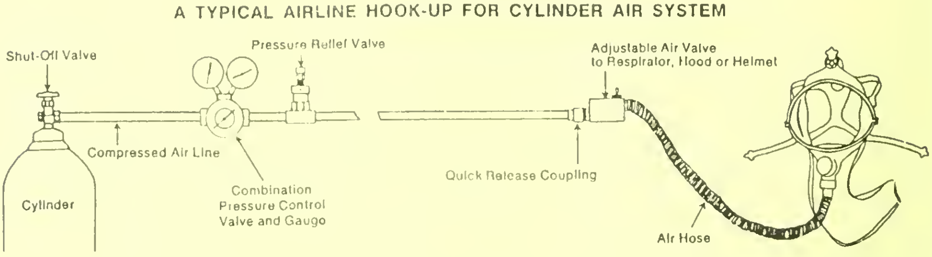


Figure 4-3 Air Line Respirator

Combination air line units include both an air line respirator and an egress only S.C.B.A. In the event of an emergency the user can disconnect from the air line and breath air supplied from the egress bottle. Egress bottles are intended to be used as escape devices only and should never be used for an entry into a confined space.

S.C.B.A. Cleaning & Maintenance

Each component of the S.C.B.A. and the hose-line system requires specific maintenance to retain its original effectiveness. An acceptable program of care and maintenance includes:

1) Cleaning and Sanitizing by washing components

in 50 ^{o}C water with a mild detergent or with cleaner recommended by the manufacturer. Then rinse components thoroughly in clean, warm; 50 ^{o}C maximum preferably running water and drain. Respirator components should be immersed for 2 minutes in a hypochlorite solution (50 mg/L of chlorine) made by adding approximately 1 mL of laundry bleach to 1 litre of water 50 ^{o}C, then rinse. The importance of thorough rinsing cannot be over emphasized. Dry thoroughly with a clean dry cloth. A lens defogging agent should be used at temperatures below 0 ^{o}C.

2) Inspection Testing and Repair. Steel, aluminum and composite cylinders after each use should be cleaned and visually inspected for external damage to the paint, metal or fibres. Cylinders should always be put away fully charged ready to use. An empty cylinder with no pressure inside will freely admit dirt and moisture through the valve. SCBA cylinders should have the valve removed and be visually inspected internally for corrosion and signs of pitting. The visual inspection plan (VIP) is cheap and should be done yearly by an authorized facility. (Suppliers and dive shops can perform this service). Steel

and aluminum cylinders must be hydrostatically tested every five (5) years. Composite cylinders must be hydrostatically tested every three (3) years. Never use any cylinder that has exceeded the hydrostatic date stamped on the cylinder neck.

All reputable certified breathing air refill stations will refuse to fill expired cylinders. Cylinders that are fully charged and used infrequently should be emptied and refilled with "Certified Breathing Air" every 3 months. Smells of garlic, oil and mustyness are indications of cylinder air contamination. If a cylinder is suspected of being contaminated, refuse to use it and replace it with a fresh cylinder.

Foot Protection

Foot protection is required in all confined spaces. The feet are exposed to injury from:

1. Falling objects.
2. Corrosive or toxic substances.
3. Sharp objects.
4. Extremes of heat, cold and moisture.

Foot protection should be C.S.A. approved and should be waterproof (work safety boots are not considered waterproof only rubber safety boots are). Footware that has been damaged by abrasion, crushing blow, wear and tear must be replaced when they

no longer conform to the regulations of the O.H.S.A.

Hand Protection

Gloves of a suitable type are necessary when working in confined spaces with the following hazards.

1. Corrosive or toxic substances.
2. Infectious substances.
3. Welding, burning, cutting operations.
4. Sharp or splintered materials.
5. Temperature extremes, and
6. Electrical operations.

In addition to providing protection from the above hazards, gloves keep the hands relatively clean resulting in better personal hygiene.

Protective Clothing

When confined space workers are exposed to the hazard of injury from skin contact with any hazardous substances or objects, they should wear apparel sufficient to protect them from injury.

Clothing such as coveralls, gloves, rubber boots etc., worn when handling potentially hazardous substances or when working around raw sewage is necessary to isolate the worker from the insidious hazards of sharp objects, infectious matter and general

abrasion of exposed areas.

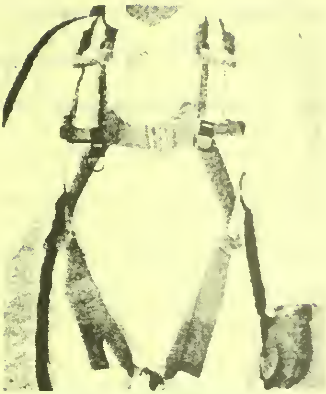
Protective clothing worn when entering confined spaces should be cleaned and disinfected prior to being worn by another person and should be cleaned and stored in lockers separate from street clothes.

This aspect is important and will not only protect the worker but also his family from accidental transmission of toxic and infectious contaminants.

GENERAL PROTECTIVE EQUIPMENT

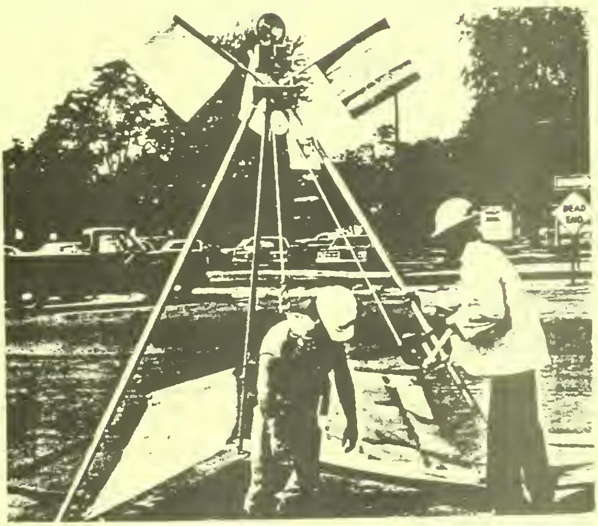
Lifelines & Harnesses

Lifelines and parachute harnesses are required by any worker who is exposed to a falling hazard in a confined space. Also a suitable method of arresting a fall must be used in conjunction with the lifeline and harness.



Parachute Harness
Front mounted type

Parachute Harness
Rear mounted type



Parachute harness used in conjunction with man-hoist and tripod system.

Figure 4-4 Harnesses

In a confined space only a parachute type safety harness (Figure 4-4) may be worn. The harness prevents a limp body from falling out of it. The lifeline connection should attach near the shoulders so as to suspend a body in the upright position. Tilting or doubling over of a body can prevent its rapid removal through a confined space opening, or cause injury to a person while being removed in the doubled over or tilted position.

The harness and lifeline may be used to lower a worker into a confined space. Whenever a worker is in a confined space, someone must be topside holding the lifeline and observing the actions of the worker in the harness. Do not tie the above ground end of the lifeline to any object that could be hit by a careless driver. Doing so could result in injury to the worker in the harness.

Safety lines, or harnesses that have been involved in an actual falls should be inspected and replaced as necessary. The inspection should be made by a "competent person" authorized to do so. Ropes and harnesses retired from service should be destroyed or marked so they can not be confused with safe functional equipment.

Lifelines should conform with C.S.A. standard Z259.2 (1979) or be at least 1/2 inch diameter nylon, 1/2 inch diameter polyester, 3/4 inch diameter first-grade manila or 3/8 inch diameter steel cable, all with a minimum breaking strength of 5400 lbs. Currently, 12/16 inch diameter manila rope may be required to meet the 5400 lb. breaking strength requirement.

Steel cable should be used only in spark or heat producing work operations. Ropes must always be protected from abrasive or cutting edges which may weaken the rope. Weather-protected nylon and polyester lifelines with neoprene jackets are available. Polypropylene ropes are popular with utilities because of the low moisture absorption and high dielectric constant.

Ventilation Equipment

The O.H.S.A. requires that mechanical ventilation shall be continued while work is being carried out within the confined space enclosure. This serves to provide protection in case of accidental release of chemicals, to remove contaminants produced by the work carried out or to cool the enclosure. Openings should be provided for the entry of clean replacement air. To ensure thorough ventilation, the points of air supply and exhaust should be separated as far as possible. Free oxygen should never be used to ventilate a confined space. Hot confined spaces should be allowed to cool before entry. Inert gas used in purging should be removed before entry.

To accomplish adequate ventilation of a confined space "normal air" can be supplied by a fan or blower, or the atmosphere in the confined space can be exhausted through a fan or blower (Figure 4-5). The most effective method of ventilating a confined space is to place a ventilator hose at the bottom of the space and blow in fresh air. This will displace any gases contained in the space and force them out of the opening.

Ventilation equipment intakes should be placed so that only normal fresh air is drawn into the ventilator. Care should be taken not to place ventilators downwind of vehicle exhaust pipes or other sources of atmospheric contamination.

Ventilation equipment, whether fixed or portable, must be able to provide for a minimum of 10 air changes per hour in the confined space. If a single portable ventilator is not capable of 10 air changes per hour, additional portable units will be required until 10 air changes per hour can be maintained.

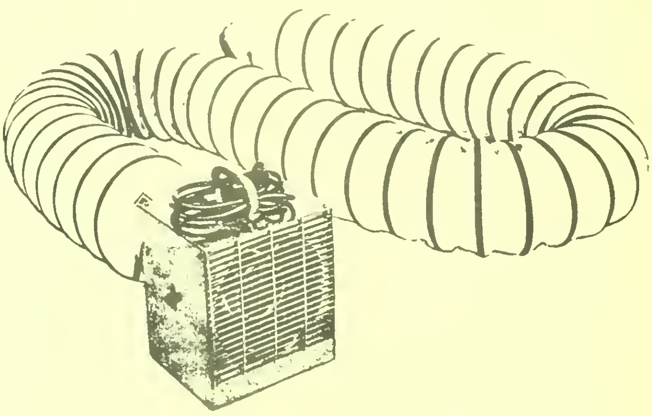


Figure 4-5 Ventilation Equipment

Lifting/Fall Arresting Devices

Lifting and fall arresting devices are required when confined spaces are entered by workers who may be exposed to slipping, falling or may require rescue from a confined space.

Sections 55, 56, 89 of the O.H.S.A. Regulations for

Industrial Establishments outline the requirements for such devices and stipulates compliance with Canadian Standards Association guidelines for the construction and testing of such devices.

Lifting devices can be separated into 2 categories, those that are used to carry tools and equipment and those that are used to carry humans. Lifting devices employed for safety and rescue operations should never be used for handling material or equipment. Lifting devices must be equipped with adequate braking which will automatically prevent the load from falling.

Lifting devices shall be inspected at least annually by a competent person to assure safe working operation. A record has to be kept on each unit containing appropriate check sheets and results of inspection and tests. Any lifting device exhibiting distortion, cracks, frayed cables etc. should be taken out of service and replaced or repaired. Only "competent persons" should repair, maintain and operate lifting devices. A lifting device mounted to a vehicle must never be used to lift or lower personnel. In the event that the vehicle is involved in an accident, the confined space worker will surely be injured.

<u>Lock Outs & Blanks</u>

When the possibility of being injured exists by operating machinery, energized electrical circuits and pipes or vents carrying contaminants into a confined space, it is necessary to use lockouts, blanks and blocks to ensure worker protection.

The term "Lock Out" (Figure 4-6) refers to any action carried out by a worker that will immobilize a machine or process from operating while work is conducted within the confined space. This procedure includes:

1. De-energizing electrical circuits, including automatic or remote starting systems (e.g. computer control).
2. Bleeding off excess pressures in hydraulic pneumatic, steam or product lines.
3. Blanking off lines by physical separation or insertion of a blank of sufficient strength to contain any pressures within the line.
4. Blocking or chocking of machinery to prevent movement of its integral components.
5. Chaining of valve handle mechanisms in their desired position.

When equipment is locked out proper checks should be made to ensure that the machine that was locked out is indeed inoperative.

"Blanking off" (Figure 4-7) means that all lines and systems which may introduce hazardous material into the confined space shall be physically disconnected and blanked off. The blanks should be sufficiently strong to withstand the line pressure and not be susceptible to corrosion by the material within the lines. Experience has shown that valves which are closed may leak.

Therefore, merely shutting off the valve is not adequate.

Experience has also shown that the accidental starting of machines while others are working on them is one of the major causes of amputations and fatalities. Work on machines is seldom routine. It is often done during other than normal working hours. There is usually a sense of urgency. It may be a first experience for some workers. Certain large installations may require several trades, each working under a different foreman who has his own ideas regarding safety conditions. Workers may be separated or out of communication with those near the control switch. All of these factors contribute to the possibility of the accidental starting of a machine and emphasize the need for the use of lockouts & blanks

Figure 4-6 LOCK OUTS

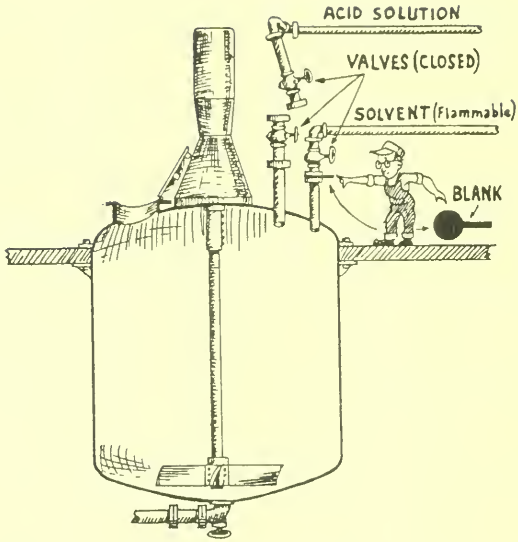


Figure 4-7 BLANKING OFF

Atmospheric Sensing Equipment

The operation principles of sensing equipment is covered in Topic 3, however, it is important to realize that sensing equipment reliability depends upon:

1. Atmospheric pressure.
2. Ambient temperature.
3. Relative humidity.
4. Shelf life of detection tubes and cells.
5. Proper routine calibration.
6. Battery voltage, and
7. User competence.

It is imperative that the user is fully familiar with the manufacturers recommendations for operation, maintenance and calibration of the equipment, in order to achieve meaningful results that will ensure worker safety. It is equally important that the user follow the same recommendations.

Non Sparking Tools

Non sparking tools are used in confined spaces when combustible vapours could be present or possibility of ignition exists.

These tools are made from beryllium copper alloy, monel or rubber and have several distinct advantages and disadvantages. Advantages of non sparking tools include, lessened chance of a spark causing ignition of flammable liquids and vapours, non corrosive, and light weight. The disadvantages include a tendency to fail and shatter under extremes of force (e.g. torque, repeated blows). When conditions of confined space work dictate the use of non sparking tools, no substitutions for tools that aren't sparkless should be allowed. However, the confined space may be rendered safe by additional ventilation, neutralization or inerting to allow the use of conventional tools. Non sparking tools come in a wide variety for all applications. (Figure 4-8).

FIGURE 4-8 NON SPARKING TOOLS

Warning Devices

Warning devices are necessary when the possibility of traffic injuries may occur. Equipment required could be:

1. Traffic cones.
2. Signs & flags.
3. Barriers, and
4. Beacons.

In addition to the above equipment a flagman may be required as well, depending on the situation. In all cases requiring entry to confined spaces on public road allowances, the signing should comply with the Traffic Control Manual for Roadway Work Operation put out by the Ministry of Transportation and Communications, 1981.

Other warning devices should include:

1. Vehicle flashers & beacons.

2. Continuous action emergency horn.
3. Communications equipment, and
4. A megaphone.

These additional devices will make confined space rescue operations shorter in duration and will expedite help to the emergency location.

IMMUNIZATION & PERSONAL HYGIENE

Personal health maintenance is primarily the responsibility of each individual, however, due to the nature of the work done in certain confined space operations, preventive health measures are deemed necessary to protect workers against health hazards in their work environment.

Exposure to physical and chemical hazards in the workplace is easily limited by the correct use of protective equipment. On the other hand, biological hazards such as:

1. Pathogenic bacteria, and
2. Diseases transmitted by vermin and insects,

must be handled in a different manner.

Effective protection of disease from pathogenic organisms is most easily accomplished by immunization. These diseases can include:

1. Polio.

2. Tetanus.

3. Typhoid.

4. Hepatitis.

5. Cholera, and

6. Dysentery.

Table 4-2 outlines the immunization frequency that is recommended when workers are exposed to pathogenic bacteria.

TABLE 4-2

Polio:	A 3 injection series at birth and booster every 10 years.
Tetanus:	A 2 injection series at 1 year and boosters every 10 years or with injury if greater than 5 years from last booster.
Typhoid:	3 injection series in a 6 month period and booster every 2-3 years.
Type A Hepatitis:	2 injections in a 5 month period (marginally effective).
Cholera:	No vaccine, no reported cases in Ontario.
Dysentery:	No vaccine, good personal hygiene is an effective prevention.

Diseases transmitted by vermin can include rabies. Effective rodent control measures will limit chances of exposure. Insects can inflict bites that can be either venomous (Black Widow spider) or nonvenomous. Insect bites are good vectors for

secondary infections. If accidental exposure to disease occurs prompt medical treatment is the effective method of control.

Practice of good personal hygiene will go a long way in preventing infection or irritation from physical, chemical or biological contaminants. The following is a list of standard practices that make good sense.

1. Use protective equipment such as gloves, aprons, goggles and face shields to avoid skin contact potentially harmful materials.
2. Thoroughly wash all exposed body parts (hands, face, etc.) immediately after handling potentially harmful materials and before eating, smoking, drinking or performing ablutions.
3. Clean all safety equipment such as safety harness, face mask, gloves etc. after each use.
4. Food, beverages or tobacco shouldn't be taken into a confined space or consumed in any area where potentially poisonous or hazardous materials may be present.
5. Where workers are exposed to poisonous or infectious substances, work clothing should be kept in a locker separate from street clothing.
6. Contaminated clothing should never be worn in eating areas and should be laundered separately.

The previous list is by no means complete and workers should exercise their own best judgement when special situations arise.

PERSONAL TRAINING

Although workers think that they are experienced to perform the routine tasks of their jobs, most workers have to call on special skills learned by additional training. Confined space work requires that the worker be "Competent". Competency is achieved only by a combination of experience and training.

Confidence is achieved when a worker is familiar enough with a procedure or task that the thought of performing such tasks don't instill doubt in the workers mind. This too is best accomplished by experience and training.

Training courses such as:

1. First Aid.
2. CPR, and
3. Entry to Confined Spaces,

and others will go far in giving the worker confidence and competence in his work.

Confined space work is changing rapidly and workers will be safer if a program of training and retraining is followed. Advances in technology in such areas as atmospheric sensing and respiratory protection have ensured that the future survival rate of workers is not directly linked anymore to the life of a

canary.

SUMMARY

The wearing of Protective Equipment never eliminates the hazard. It serves to protect the wearer from the hazard.

When using any Protective Equipment, it is vital that the correct type, to protect against the specific hazard, be used. No one type of eye protection can protect against all eye hazards. There are no "Universal" Safety Gloves or Hand and Finger protection which is best for all types of hazards.

All Protective Equipment must be correctly fitted and properly worn to be at maximum effectiveness in preventing injury. Carelessness could result in an injury or even a fatality. Unless the worker is experienced in fitting and adjusting safety equipment, adjustments should be done by someone trained to do them. This is important in all types of Protective Equipment but especially for Safety Hats, Life Belts and Respiratory Devices.

All Protective Equipment should be kept clean and in good condition. Repairs should be made only by personnel authorized and only when original safety protection can be restored.

Protective Equipment serves to protect not only against known hazards but also against hazards which are not expected and also in all kinds of emergencies. The wearing of Safety Glasses,

Safety Hats, Safety Shoes, and Safety Gloves, even if not required by safety rules, could serve as positive insurance against many unexpected hazardous conditions.

Workers should constantly be on the alert to spot defects or faults which occur in their safety equipment. All such conditions should be reported to the supervisor and the equipment should not be worn again until it is checked out and repaired or replaced.

SUBJECT:

CONFINED SPACE ENTRY WORKSHOP

TOPIC: 5

Entry Procedures

OBJECTIVES:

The Trainee will be able to:

1. List the requirements necessary for a safe entry into a Confined Space as established under Sec. 72-75 of the Regulations for Industrial Establishments of OHSA.

2. List the duties of a guard.

3. Identify the correct method of sensing the atmosphere in an open and closed confined space.

4. Identify correct entry procedures.

ENTRY PROCEDURES

GENERAL

The rule for any systematic approach to entering and working in confined spaces is to assume that a hazard exists.

Entering the confined space without adequate protection and testing of the area may jeopardize the health and safety of the worker.

To ensure that work in a confined space is undertaken to minimize the possibility of accidents minimum safety requirements have been established by the Ministry of Labour and are outlined in Section 72, 73, 74 and 75 of the OHSA in Regulations for Industrial Establishments. In some cases, the minimum requirements of the regulations have been exceeded by the Ministry of the Environment. If any of the requirements are bypassed or violated and an accident occurs, the immediate supervisor and/or the employee can be charged with an offense. Reasonable variations may be acceptable but the Ministry of Labour, responsible for the enforcement of the Act, will not overlook violations.

Anyone who is required to work in a confined space or in support of those who do must be familiar with the pertinent sections of the Occupational Health and Safety Act and Regulations and must be properly trained to perform a safe confined space entry.

Occupational Health and Safety Act

The requirements of the following sections of the Occupational Health and Safety Act and Regulations apply with all necessary modifications to any confined space while a worker is in that space.

Section 72 Subject to Section 74, a confined space shall be entered only where:

a) there is a easy egress from all accessible parts of the confined space.

b) mechanical equipment in the confined space is:

   i) disconnected from its power source, and

   ii) locked out.

c) all pipes and other supply lines whose contents are likely to create a hazard are blanked off; and

d) the confined space is tested and evaluated by a competent person who:

   i) records the results of each test in a permanent record, and

   ii) certifies in writing, in the permanent record, that the confined space

      (A) is free from hazard, and

      (B) will remain free from hazard while any worker is in the confined space, having regard to the nature and duration of the work

to be performed.

Section 73 Subject to Section 74, a confined space in which there exists or is likely to exist

a) hazardous gas, vapour, dust or fume; or

b) an oxygen content of less than 18% or more than 23% at atmospheric pressure.

shall be entered only when.

c) when the requirements of Section 72 are compiled with.

d) the space is purged and ventilated to provide a safe atmosphere.

e) the measures necessary to maintain a safe atmosphere have been taken.

f) another worker is stationed outside the confined space.

g) suitable arrangements have been made to remove the worker from the confined space should he require assistance, and

h) a person adequately trained in artificial respiration is conveniently available.

Section 74 A confined space in which there exists or is likely to exist.

a) hazardous gas, vapour, dust or fume, or

b) an oxygen content of less than 18% or more than 23% at atmospheric pressure.

and which can not be purged and ventilated to provide and maintain a safe atmosphere shall be entered only

when.

c) all the requirements of Section 72 except subclause (d) (ii) are compiled with

d) the worker entering is using a suitable breathing apparatus and a safety harness or other similar equipment to which is securely attached a rope, the free end of which is held by a worker equipped with an alarm who is keeping watch outside the confined space.

e) the worker entering is using such other equipment as is necessary to ensure his safety.

f) the safety harness, rope and other equipment mentioned in Clause (d) have been inspected by a competent person and are in good working order, and

g) a person adequately trained in artificial respiration is conveniently available.

<u>Section 75)</u> (1) Subject to Section 2 where the gas or vapour in a confined space is or is likely to be explosive or flammable the confined space shall be entered only where:

a) the concentration of the gas or vapour does not or is not likely to exceed 50% of the lower explosive limit (LEL) of the gas or vapour, and

b) the only work to be performed is that of cleaning or inspecting and of such a nature that it does not create any source of ignition.

(2) Cold work might be performed in a confined space which contains or is likely to contain an explosive or flammable gas or vapour where the concentration does not and is not likely to exceed 10% of the lower explosive limit (LEL) of the gas or vapour.

SAFETY EQUIPMENT

Safety equipment required for a confined space entry must include:

1. Approved detection and sensing devices to determine oxygen, combustible and toxic content of the atmosphere in the confined space.
2. An adequate ventilation system (explosion proof type if required).
3. A self contained breathing apparatus (SCBA) of at least 30 minute duration.
4. A man hoist or lifeline retrieval unit.
5. Other equipment includes parachute type harness, lifeline, hardhats, safety boots, rope, safety lights, manhole cover lifter, traffic control, (i.e. barriers, vests, cones, etc.) audible warning alarm, extension ladder if required and any other equipment for special conditions that might exist in the confined space.

Note

Where practical, a lifeline-retrieval unit is used by the Ministry of the Environment personnel to allow two-man teams to perform a confined space entry. This replaces the additional manpower required to remove casualties from the confined space.

Other Equipment Considerations

Hand tools should be clean, in good condition, and should be selected carefully according to the uses intended. Portable power tools and equipment should be clean and in good condition. Electrical cords should be grounded and not cut or frayed. The increased use of Ground Fault Interrupter Circuits in areas where electrical circuits are exposed to water is a mandatory protective device when using power tools in confined spaces.

If the confined space is likely to accumulate combustible gases or fumes, the equipment should be of the explosion-proof type. Ladders used in confined spaces should be lashed at the top and, if possible, at the bottom as well.

Employees performing electrical welding should use insulating blankets and other personal protective equipment as necessary. Welding and cutting torches must never be taken into the space until needed and must be removed from the space immediately after use. Cigarette lighters, matches must not be

allowed in confined space.

Cylinders of oxygen or other gas should never be taken into confined spaces and should be turned off at the cylinder valve when not in use.

Special signs posted near the work area help to keep the area clear, ensure that potentially harmful operations will not be started independently nearby, and help to guide rescuers should it be necessary.

ATMOSPHERIC TESTING PROCEDURE

Many portable instruments to measure oxygen levels and detect the presence of combustible and toxic substances are available. When a confined space atmosphere is tested, the three hazard classes should be checked for in the following order: oxygen deficiency, combustibility and finally toxicity.

First, a test for oxygen deficiency followed by tests for combustible and toxic gas accumulations should be made with a probe near the entry point. The cover should be removed only after the initial probe has been completed. Great care should exercise in removing the cover. If combustible gases are present a spark could cause an explosion.

The space should be tested, from top to bottom. Special attention should be paid to any lines, ductwork, vents or pipes within the space. The tendency of certain gases to pocket in

depressions and irregular surfaces should be kept in mind and all crevices and corners should be tested carefully. Once the oxygen combustible and toxic gas readings have been taken, the readings should be recorded in a permanent record.

NOTE

> With some types of testing devices oxygen is required to support combustion of a flammable gas or vapour. If an oxygen deficient atmosphere exits in a confined space, the concentration readings of the combustible gas or vapour may be false due to a lack of oxygen. A flow through or sample draw device should used to test for combustibles when low oxygen levels exist in confined spaces.

The testing device must be equipped with an audible alarm or a meter and preferably be capable of monitoring for oxygen, combustible and toxic gases (tri-tector) simultaneously. In some cases, a tri-tector may not be available and several different instruments may be required to be used.

The testing is conducted prior to initial entry and must continue while the confined space is occupied to ensure conditions do not deteriorate.

If an alarm is received at any time during the entry procedure, the worker must not enter the space or he must leave

the space immediately.

1. Normal oxygen content in air is approximately 20.9%. Most oxygen detectors alarm at 19.5% oxygen content. The 19.5% set point allows sufficient O_2 concentration to be present in the atmosphere for a safe entry at higher altitudes. The Ministry of the Environment does not allow employees to enter if an alarm is received at 19.5% or a meter shows anything less or greater than 20.9% oxygen except for emergencies in which case a SCBA is worn.
   The Ministry of Labour regulations indicate entry must not be made when the oxygen content is below 18% or above 23%.
2. Ministry of the Environment workers do not enter a confined space if toxic or combustible gases are detected except for emergencies in which case a SCBA is worn.

VENTILATION

Any confined space, regardless of its contents, must be ventilated to eliminate oxygen deficiency and any accumulated combustible or toxic substances. Ventilation should continue throughout the time a worker is in the confined space. The most efficient way to vent a confined space is to introduce fresh air near the bottom of the space. Any system of positive ventilation must maintain a constant flow of fresh air through all areas of

the space.

When combustibles are purged, any spark source outside the space, such as an electric or internal combustion motor, should be kept away from the ventilator discharge system. Oxygen should never be used to purge or ventilate a confined space. Oxygen concentrations in excess of 23% significantly increase the combustibility of other substances in the space.

After the space has been ventilated, the atmosphere should be retested for oxygen deficiency, combustibility and toxicity. During the retest (with vent fan off), the same steps should be followed and the results recorded. If the atmosphere is not within allowable limits for any hazard, further ventilation will be necessary.

Ventilation of the confined space must be conducted during an entire confined space entry procedure. Air is induced into the space under a positive pressure as opposed to extracting it to ensure those gases which are heavier than air are forced out of the space. Also, induced air will maintain a positive pressure within the confined space that helps to reduce the possibilities of other atmospheric contaminants from being drawn into the working area.

DUTIES OF A GUARD

The person to act as guard at the access point to a confined space should be trained in resuscitation and selected by those

who are to enter the space. The person selected to be the guard should be one who knows the possible hazards, knows what action to take should an emergency develop, and is able to organize additional help without delay in emergency situations.

When a guard has been appointed, it becomes the guard's duty to oversee all phases of the work in the confined space. Also, it is the guards responsibility to ensure the following.

1. The protective equipment required for the entry is on hand, in use and worn by those entering the space.
2. An atmospheric record has been completed prior to entry.
3. The personnel in the confined space are kept under observation.
4. Assistance is given to the personnel in the confined space as they require it.
5. The access point is guarded at all times. If it becomes necessary for the guard to leave, even for a few minutes, the personnel must leave the confined space for the duration of the guard's absence, or another competent person must be detailed to act as a temporary guard.
6. Adequate assistance is available should emergency removal from the confined space become necessary.
7. The confined space <u>is never entered</u> to perform

a rescue unless adequate personnel are on hand to provide assistance to the rescuer and the rescuer is wearing a safety harness, safety line and a self contained breathing apparatus.

ATMOSPHERIC RECORD

As required by the regulations of the Occupational Health and Safety Act the readings obtained from a confined space must be entered in a permanent record. In addition it must be certified <u>in writing</u> that the area is free of hazards, and will remain free of hazards in respect to gases and oxygen deficiency for the duration of the entry. This then is the "Atmospheric Record".

The Ministry of Labour has advised that records of entry readings must be retained for a minimum of two years to comply with the Regulations.

In signing an atmospheric record prior to an entry into a confined space the person signing is stating that the area is safe for entry at the time shown, and that as far as the signator can determine, the space will remain free of hazards for the duration of the entry. Atmospheric records should contain the following information:

1. Date and time.
2. Types and location of confined space.

3. Detection device make, model and serial number.

4. Oxygen concentration.

5. Combustible gas concentration.

6. Toxic gas concentration

7. Signature of the competent person performing the atmospheric tests.

8. Remarks and comments.

Examples of different Atmospheric Records are shown in Figure 5-1.

Ministry of the Environment
Ontario

Confined Space Atmospheric Record

Date of Entry			Confined Space Type & Location	Atmospheric Sensing & Detection Device		Atmospheric Readings			Signature of Atmospheric Testing Person	Time
D	M	Y		Serial #	Make & Model	O2 %	Toxic	Comb.		
										: M
										: M
										: M
										: M
										: M

NOTES:

CONFINED SPACE ENTRY

VEHICLE NUMBER OR PLANT

DATE & TIME	LOCATION (BE SPECIFIC)	TOXIC (POLY)	COMB	O_2	INITIALS (PRINT)

Figure 5-1
Atmospheric Records

CONFINED SPACE ATMOSPHERIC RECORD

SPECIAL NOTE: THE REGULATIONS OF THE O. H. S. A. AND THE MINISTRY OF THE ENVIRONMENT SAFETY MANUAL COVERING CONFINED SPACE ENTRY SHALL HAVE BEEN MET PRIOR TO AN ENTRY BEING MADE.

19__ Date	Item	Location	Entry For	Readings			Detection Device					Entry Authorization	Time
				O_2	Exp	Tox	Make	Type/Model	Serial	Date Cal	Cal By		

ENTRY PROCEDURES

To ensure that the requirements of the OHSA, its regulations and the Ministry of the Environment safety policy are met, a competent person must supervise the work. He will,

a) Brief the workers on the particular job and, if appropriate, any special arrangements that are required to carry out the work. Each worker should know what his particular function is.

b) Ensure that the workers are properly equipped with personal protective equipment.

c) Lock out and tag all associated electrical circuits and equipment and intake valves.

d) Appoint a competent person as a guard.

e) Check the sensing device for serviceability and calibration. Recalibrate if necessary.

f) Sense the area for

   1) Oxygen level. Must be 20.9%.

   2) Explosive Gases. Must be 0.0%.

   3) Toxic Gases. Must be 0.0%.

g) Enter the readings and other required information in the Atmospheric Record.

h) Commence ventilation of the confined space. Ventilate for at least five minutes or until acceptable readings are obtained. Continue ventilation for the duration of the entry.

i) Inspect the safety harness(s).

j) Inspect the safety rope and ensure it is properly attached to the harness.

k) Ensure the safety rope is properly attached to the man-hoist or if a man-hoist is not available, some immovable object close to the guard.

l) If a man-hoist is not available, ensure that an adequate number of personnel conveniently located nearby for emergency removal of the worker.

m) Ensure that a spare safety harness, safety rope and a SCBA are on-hand and serviceable.

n) If a detection device is not worn by the worker entering the confined space, ensure that the area is sensed continuously during the entry.

o) Check emergency horn for operation.

Special Entry Requirements

The Ministry of the Environment Safety Policy establishes certain special requirements when cleaning or repairing of digesters/sludge holding tanks is carried out. These are attached as an Appendix and should be reviewed by all confined space entry course candidates.

DIGESTER/SLUDGE HOLDING TANK OVERVIEW

Digester/sludge holding tank cleanouts, place stringent requirements on all personnel if the operation is to be done safely. When operating a digester or sludge holding tank:

1. Cease all pumping to the structure for a minimum of forty eight (48) hours prior to opening the manholes.
2. Close and lock out all intake valves leading into the structure.
3. If the structure is a digester, place all mixers in continuous operation for a minimum of twenty four (24) hours and feed the gas to the waste gas flare stack.
4. After twenty four (24) hours, shut off the mixers and lock out of service.
5. If repairs only are to be made to mixers or equipment on the roof area, close all outlet valves to the structure.
6. Release stored gas within the structure by removal of one (1) weight from the Vacuum Pressure Relief Valve Assembly. Leave the area for a minimum of one (1) hour and allow gases to escape to atmosphere. Repeat this

procedure until all the gases are vented. Remove remaining weights.

7. One (1) hour after the final weight has been removed, raise the valve from its seat and remove or block up off the seat, using a wedge.
8. Commencing on the downwind side of the structure roof, remove the securing device from the hatch cover. Remove the cover.
9. Continue to remove the hatch covers, working upwind on the roof at all times.
10. When the final hatch is opened, leave the area for a minimum of four (4) hours to allow the gas and vapours to escape to atmosphere.
11. After a minimum of four (4) hours, if no visible vapours are observed to be issuing from the structure, place an explosion-proof ventilating fan with a minimum capacity of 2.60 m^3/s (5500 cfm) over the upwind hatch and commence inducing air into the structure.
12. On a regular basis, a minimum of three (3) times in an eight (8) hour period, the fan is to be removed from service, after a minimum of five (5) minutes have elapsed, the interior structure is to be tested for Oxygen content, Explosive and Toxic gases. The tests are to be performed by a competent person, using an approved detection device.

13. Each operation is to be recorded in the log, showing the time of the operation and the name of the person performing the work.

DIGESTER CLEANOUT

When cleaning a digester the following procedures should be followed:

1. Valves on all piping leading into the structure from other areas should be fully closed and locked. Keys to these locks can be retained by the supervisor or a competent person appointed by the supervisor.
2. All gas or sludge piping leading into the structure from other areas should have a section of the piping removed and all piping blanked off to prevent a leak.
3. After any break between work periods (e.g. noon hour, overnight, etc.) occurs or if the area has been vacated, resumption of work must be treated as a new operation and all procedures observed.
4. No entry should be made into the structure until at least 30 cm (12 ins.) of floor is sludge free from the wall of the structure.
5. If an accessible bulkhead door is fitted to the structure, it should be opened as soon as possible, to increase ventilation to the

structure and as a means of entry and egress.

If it is necessary to use compressed air to break up the solids in a digester or sludge holding tank, the pipe from the compressor hose into the area must be plastic or aluminum only. Steel piping is not recommended due to the possibility of sparking.

During use of the compressed air, Hydrogen sulfide gas (greenish vapours) may appear in the area of the pipe discharge into the sludge. Remove the pipe to another location or shut down the air supply until vapours dissipate. It is recommended the area be evacuated for one (1) hour before resumption of work, due to the explosiveness and toxicity of the vapours.

Floating roof digesters require the contents to be lowered first, permitting the roof to rest on the corbels before the digester gases can be vented.

SUBJECT:

CONFINED SPACE ENTRY
WORKSHOP

TOPIC: 6

Emergency & Rescue

OBJECTIVES;

The Trainee will be able to:

1. Identify and tie the 5 required knots and 1 hitch and list their applications.

2. List the reasons why a stretcher needs to be properly blanketed and lashed during casualty evacuation.

EMERGENCY & RESCUE

GENERAL

When working in a confined space emergencies can arise from:

1. Physical injury.
2. Toxic or combustible gas alarm.
3. Oxygen deficiency.
4. Equipment malfunction or failure.
5. Medical emergency.

If any of these situations occur then the confined space workers are faced with a real emergency and may have to effect a rescue of an injured or unconscious person.

The outcome of an emergency can be reduced by adequate training of personnel in emergency and rescue procedures, equipment operation, first aid and Cardio Pulmonary Resuscitation (CPR).

The prerequisites necessary prior to attending the Confined Space Entry Workshop are training in First Aid and CPR. The routine testing and usage of protective equipment should give the worker adequate training and knowledge of equipment operation. This topic will outline some of the additional skills necessary to act effectively during an emergency and rescue of a worker.

During an emergency, an unusual event has happened that

renders the confined space dangerous to human activity within it. Human nature instinctively insists that we help our fellow man. Rushing into a confined space unprotected and unprepared is suicidal and will only complicate the eventual rescue. Some steps to remember are:

1. Perform all checks necessary to enter a confined space <u>prior</u> to entry.
2. Have, check, calibrate and use all the equipment necessary for safe performance of work within the confined space.
3. Set up, check and prepare for a confined space emergency. (Items such as flashing beacons, stretcher, blankets, resuscitator, radios, etc., all significantly reduce the severity of any emergency).
4. Be able to summon help fast in an emergency. (horns, radios, walkie-talkies, etc.).
5. Perform the rescue quickly, but calmly and always safely.
6. Perform First Aid or CPR as necessary to stabilize the victim and evacuate to a medical facility as quickly as possible.
7. Secure the confined space for inspection and investigation by supervisor or other parties.
8. Record and make note of the emergency as soon as practically possible after the emergency has ended. Be concise and

detailed about the events prior to, during, and after the emergency. The notes made just after an emergency often tend to be advantageous in answering questions in the future. (Ministry of Labour, Worker's Compensation Board, etc.).

Ropes and Knots

One of the more practical skills confined space workers can acquire is the ability to tie proper knots for specific applications. Although there are many knots used for similar purposes and they could work equally well, particular attention will be paid to 5 basic knots and one hitch. Only frequent usage will ensure that the worker is competent enough to handle ropes and knots safely. The knots and hitches to be learned are the;

1. Square or Reef Knot,
2. Figure of Eight,
3. Bowline on a Bight,
4. Sheet Bend,
5. Sheepshank, and
6. Clove Hitch.

The Square or Reef Knot is a useful knot for binding purposes. Even though it is often used to tie two ropes together, it is dangerous when used to do so, since it unties easily when either free end is jerked. (Figure 6-1).

The Figure of Eight is stronger than the common overhand knot and will not damage rope fibres. This knot can also be used for lowering and raising workers. It's best use is to prevent the free end from running out of a pulley. (Figure 6-2).

The Bowline is often referred to as the "king of knots" because it is applicable for many situations. Used primarily for hitching, lifting and joining. The Bowline never slips or jams if tied properly. The Bowline makes a loop that won't tighten and it is commonly used to raise and lower workers and tools. (Figure 6-3)

The Sheet Bend or Weaver's Knot is used to join ropes of different diameters to each other. This knot when tied properly won't damage rope fibres and unties easily. (Figure 6-5).

The Sheepshank is intended to shorten a rope for temporary use only. When carefully tied and drawn up tight, it is reliable under steady pull. Permanent usage requires that the rope be seized (lashed) to the standing parts and the ends finished off with a square knot. (Figure 6-6).

The Clove Hitch is a quick, simple method of trying a rope around an object (post). It can be tied in the middle or the end of a rope. Since it has a tendency to slip when tied at the end of a rope, the end should be half hitched to the standing part for greater security. (Figure 6-7).

THE SQUARE OR
REEF KNOT

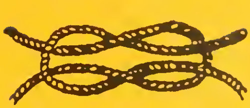


FIGURE 6-1

FIGURE OF EIGHT

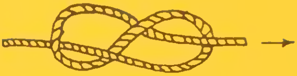


FIGURE 6-2

BOWLINE

FIGURE 6-3

BOWLINE ON A BIGHT

FIGURE 6-4

SHEET BEND

FIGURE 6-5

SHEEPSHANK

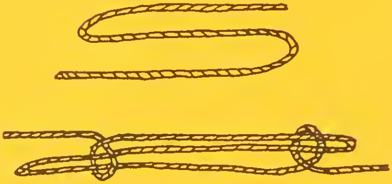


FIGURE 6-6

CLOVE HITCH

FIGURE 6-7

Casualty Evacuation

When evacuating injured workers to medical facilities, a stretcher is often used. However, there are some techniques which when used properly will reduce time and casualty shock. Blanketing and lashing a stretcher are two good techniques to accomplish this task.

The purpose of blanketing a stretcher is to treat the casualty for shock, to add to his comfort, maintain his body temperature, and to protect him from the ropes if he is lashed to the stretcher. Two blankets are used to blanket a stretcher properly. Remember it is important to put blankets under the casualty as well as over him.

Steps in blanketing a stretcher: (Figure 6-8)

1. Lay one blanket lengthwise across the head end of the stretcher, with the end flush with tips of the handles. Fold a flap down approximately one foot. Even this blanket is placed on the stretcher with blanket evenly divided on each side of the stretcher. Note: For a large person the blanket can be placed with one-third on one side and two-thirds on the other side.
2. Lay the second blanket lengthwise up and down the stretcher, approximately 18" down from the head of the stretcher. (The height of the casualty will determine this). Fold the

second blanket in three equal parts.

3. Open out the two ends of the foot of the top blanket for about two feet to form two flaps.

4. Roll or fold accordion-fashion the overhanging ends of the bottom blanket so they will not drag on the ground when the stretcher is moved.

5. Place the casualty on the stretcher, using a proper lift. Take the ends (two flaps) of the blanket over the feet. Place one flap between the ankles. Lay the second flap over the ankles, and tuck it under the legs.

6. The short side of the blanket is placed around the casualty first. A 45-degree fold is made on both sides at the head to prevent wrapping up the face of the casualty. These 45-degree folds are made to the inside of the blanket. Tuck both sides of the bottom blanket tightly. When tucking in the blanket, keep the palms of the hands down. This causes less movement to the casualty. Note: The folded portion of the bottom blanket can be used to wrap around the casualty's head.

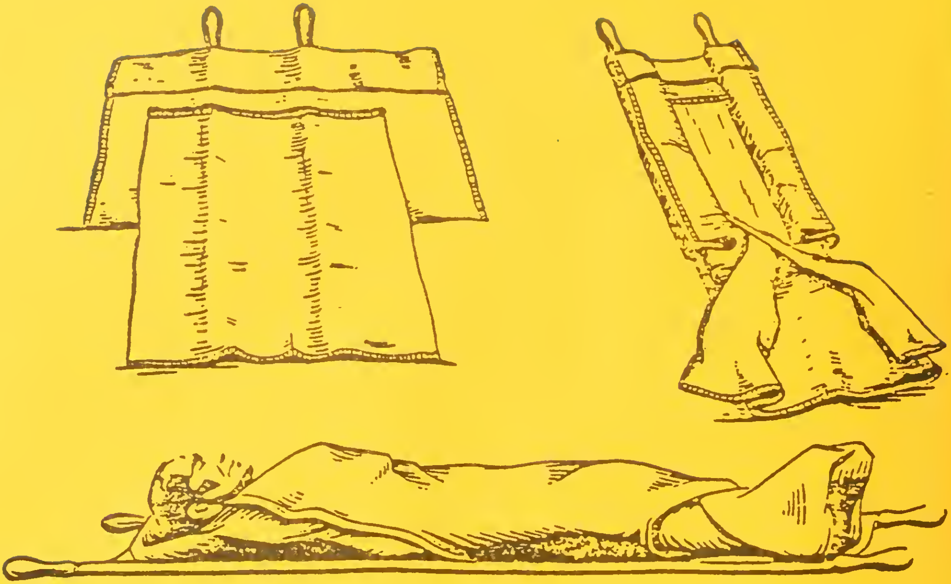


Figure 6-8

During rescue operations in which rescuers may stumble and fall, and when the casualty has to be lowered from heights, or when there is any possibility of the casualty being thrown from the stretcher, the casualty should be lashed to the stretcher.

The steps in lashing a stretcher are:

1. Using a 50' x 1/2" rope, start the lashing with a clove hitch and a safety knot on the handle of the stretcher at the head.
2. Form three half hitches around the casualty and the stretcher as directed below (Figure 6-9).

a) Across the chest (half-way between the elbow and shoulder).

b) Across the wrists.

c) Above the knees, approximately 2".

3. Then take a half hitch around the ankle and pass the rope around the casualty's feet at the instep.

4. Go back up the opposite side, making a hitch on the four half hitches that pass around the casualty.

5. Finish with a clove hitch and safety knot on the handle of the stretcher.

6. If the head of the casualty can be raised, coil the remainder of the lashing rope, and place it under his head. If the head cannot be raised, pass the remainder of the lashing rope back under the half hitches.

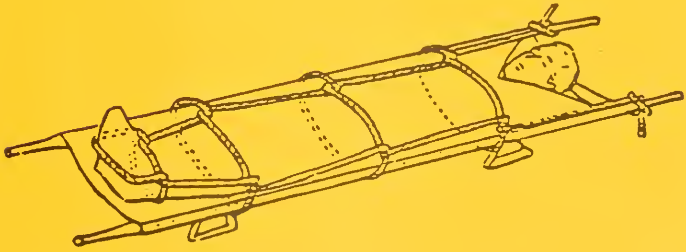


Figure 6-9 <u>LASHING A STRETCHER</u>